

Scilab Textbook Companion for  
Elements of Mechanical Engineering  
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# Book Description

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Scilab numbering policy used in this document and the relation to the above book.

**Exa** Example (Solved example)

**Eqn** Equation (Particular equation of the above book)

**AP** Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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## Chapter 2

# Fuels and Combustion

Scilab code Exa 2.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  c=88;                //% of carbon in coal
5  h=4.2;               //% of hydrogen in coal
6  Wf=0.848;           //weight of coal in g
7  Wfw=0.027;          //weight of fuse wire in
                        calorimeter in g
8  W=1950;              //weight of water in
                        calorimeter in g
9  We=380;              //water equivalent of
                        calorimeter
10 Dt=3.06;             //observed temperature rise
                        (t2-t1) in deg celsius
11 tc=0.017;            //cooling correction in deg
                        celsius
12 cfw=6700;            //calorific value of fuse
                        wire in J/g
13
14 //CALCULATIONS
15 ctr=(Dt)+tc;          //corrected temp. rise
```

```

16 Hw=(W+We)*4.18*[ctr];    //heat recieved by water in
    J
17 Hfw=Wfw*cfw;            //heat given out by fuse
    wire in J
18 Hcf=Hw-Hfw;             //heat produced due to
    combustion of fuel in J
19 HCV=Hcf/Wf;             //higher calorific value of
    fuel in kJ/kg
20 Ms=9*h/100;             //steam produced per kg of
    coal
21 LCV=HCV-2465*Ms;        //lower calorific value of
    fuel in kJ/kg
22
23 printf('The Higher calorific value of fuel , H.C.V.
    is: %5.1f kJ/kg. \n',HCV);
24 printf(' The Lower calorific value of fuel , L.C.V.
    is: %5.1f kJ/kg. \n',LCV);

```

---

## Scilab code Exa 2.2 Example 2

```

1  clc
2  clear
3  //DATA GIVEN
4  V1=0.08;                //gas burnt in calorimeter
    in m^3
5  Pg=5.2;                 //pressure of gas supply in
    cm of water
6  Pb=75.5;               //barometer reading in cm
    of Hg
7  Ww=28;                 //weight of water heated by
    gas in kg
8  Tg=13;                 //temperature of gas in deg
    celsius
9  Twi=10;                //temperature of water at
    inlet in deg celsius

```

```

10 Two=23.5; //temperature of water at
    outlet in deg celsius
11 Ms=0.06; //steam condensed in kg
12
13 //CALCULATIONS
14 //by using general gas equation , reducing the volume
    to S.T.P.
15 //p1*V1/T1=p2*V2/T2
16 p1=Pb+(Pg/13.6); //in cm of Hg
17 T1=Tg+273; //in K
18 p2=76; //in cm of Hg
19 T2=15+273; //in K
20 V2=p1*V1*T2/T1/p2; //in m^3
21 Hw=Ww*4.18*(Two-Twi); //heat recieved by water in
    kJ
22 HCV=Hw/V1; //higher calorific value of
    fuel in kJ/m^3
23 LCV=HCV-2465*Ms/V1; //lower calorific value of
    fuel in kJ/m^3
24
25 printf(' The Calorific values of fuel per m^3 of gas
    at 15 deg celsius and 76 cm of Hg pressure are:
    \n');
26 printf(' The Higher calorific value of fuel , H.C.V.
    is: %5.1f kJ/m^3. \n',HCV);
27 printf(' The Lower calorific value of fuel , L.C.V.
    is: %5.1f kJ/m^3. \n',LCV);

```

---

# Chapter 3

## Properties of Gases

Scilab code Exa 3.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  Q=-50;                                //heat rejected to
    cooling water in kJ/kg
5  W=-100;                               //work input in kJ/
    kg
6
7  //using First Law of Thermodynamics,  $Q=(u_2-u_1)+W$ 
8  Du=Q-W;                               //(u2-u1) change in
    internal energy in kJ/kg
9  //since Du is +ve, there is gain in internal energy
10
11 printf('The GAIN in internal energy is: %2.0f kJ/kg.
    \n',Du);
```

---

Scilab code Exa 3.2 Example 2

```

1  clc
2  clear
3  //DATA GIVEN
4  u1=450;                                //internal energy at
    beginning of the expansion in kJ/kg
5  u2=220;                                //internal energy
    after expansion in kJ/kg
6  W=120;                                //work done by the
    air during expansion in kJ/kg
7
8  //using First Law of Thermodynamics,  $Q=(u_2-u_1)+W$ 
9  Q=(u2-u1)+W;                          //heat flow in kJ/kg
10 //since Q is -ve, there is rejection of heat
11
12 printf('The heat REJECTED by air is: %3.0f kJ/kg. \n
    ',(-Q));

```

---

### Scilab code Exa 3.3 Example 3

```

1  clc
2  clear
3  //DATA GIVEN
4  m=0.3;                                //mass of nitrogen
    in kg
5  p1=0.1;                                //pressure in MPa
6  T1=40+273;                            //temperature before
    compression in K
7  p2=1;                                  //pressure in MPa
8  T2=160+273;                            //temperature after
    compression in K
9  W=-30;                                //work done during
    the compression in kJ/kg
10 Cv=0.75                                //in kJ/kgK
11
12 //using First Law of Thermodynamics,  $Q=(u_2-u_1)+W$ 

```

```

13 // (u2-u1)=m*Cv*(T2-T1)
14 Du=m*Cv*(T2-T1);
15 Q=Du+W; //heat flow in kJ/kg
16 //since Q is -ve, there is rejection of heat
17
18 printf('The heat REJECTED by air is: %1.0f kJ. \n',
        ,(-Q));

```

---

#### Scilab code Exa 3.4 Example 4

```

1 clc
2 clear
3 //DATA GIVEN
4 //initial state
5 p1=0.105; //pressure of gas in
    MPa
6 V1=0.4; //volume of gas in m
    ^3
7 //final state
8 p2=0.105; //pressure of gas in
    MPa
9 V2=0.20; //volume of gas in m
    ^3
10
11 Q=-42.5; //heat transferred
    in kJ
12 p=p1;
13
14 //process used- ISOBARIC (Constant pressure)
15 W12=p*(V2-V1)*1000; //work in kJ
16 //using First Law of Thermodynamics, Q=(u2-u1)+W
17 Du=Q-W12; //(u2-u1) change in
    internal energy in kJ
18 //since Du is -ve, there is decrease in internal
    energy

```

```

19
20 printf('The DECREASE in internal energy is: %2.1f kJ
    . \n',(-Du));

```

---

#### Scilab code Exa 3.5 Example 5

```

1 clc
2 clear
3 //DATA GIVEN
4 //part -1
5 //pressure=p1,temperature=T1
6 //part -2
7 //pressure=p2,temperature=T2
8
9 //Acc. First Law of Thermodynamics, Q=(u2-u1)+W
10 //when partition moved
11 DQ=0;
12 DW=0;
13 DU=DQ-DW;
14 //DU=0
15
16 printf('          CONCLUSION: \n');
17 printf('          Acc. to First Law of Thermodynamics, \
    n');
18 printf('          When partition moved, there is
    conservation of internal energy. \n');

```

---

#### Scilab code Exa 3.6 Example 6

```

1 clc
2 clear
3 //DATA GIVEN
4 //initial state

```

```

5  p1=10^5;                                //initial pressure
    of air in Pa
6  v1=1.8;                                //volume of air in m
    ^3/kg
7  T1=25+273;                             //initial
    temperature of air in K
8  //final state
9  p2=5*10^5;                             //final pressure of
    air in Pa
10 T2=25+273;                             //final temperature
    of air in K
11
12 //process used– ISOTHERMAL (Constant temperature)
13 W12=[p1*v1*log(p1/p2)]/1000;          //work in kJ/kg
14 //since W is -ve, work is supplied to the air
15
16 //since temperature is constant
17 Du=0;                                  //(u2-u1) change in
    internal energy in kJ/kg
18
19 //using First Law of Thermodynamics, Q=(u2-u1)+W
20 Q=Du+W12;
21 //since Q is -ve, there is rejection of heat from
    system to surroundings
22
23 printf(' (i) The Work done on the air is: %3.1f kJ/
    kg. \n',(-W12));
24 printf(' (ii) The change in internal energy is: %1.0
    f kJ/kg. \n',(Du));
25 printf('(iii) The Heat REJECTED is: %3.1f kJ/kg. \n'
    ,(-Q));

```

---

### Scilab code Exa 3.8 Example 8

```

1  clc

```

```

2  clear
3  //DATA GIVEN
4  p1=4*10^5;           //initial pressure
   in N/m^2
5  V1=0.2;             //initial volume in
   m^3
6  T1=130+273;         //initial
   temperature in K
7  p2=1.02*10^5;       //final pressure
   after adiabatic expansion in N/m^2
8  Q23=72.5;           //increase in
   enthalpy during constant pressure process in kJ
9  Cp=1;               //in kJ/kgK
10 Cv=0.714;           //in kJ/kgK
11
12 //gamma for air , g
13 g=Cp/Cv;
14 R=(Cp-Cv)*1000;
15
16 //for reversible adiabatic process 1-2
17 //p1*(V1^g)=p2*(V2^g)
18 V2=V1*(p1/p2)^(1/g); //final volume in m
   ^3
19 //(T2/T1)=(p2/p1)^((g-1)/g);
20 T2=T1*(p2/p1)^((g-1)/g); //final temp. T2 in
   K
21
22 m=p1*V1/R/T1;       //mass in kg
23
24 //for constant pressure process 2-3
25 //Q23=m*Cp*(T3-T2);
26 T3=Q23/m/Cp+T2;
27 //V2/T2=V3/T3
28 V3=V2/T2*T3;
29
30 //Work done by the path 1-2-3, W123=W12+W23
31 W12=(p1*V1-p2*V2)/(g-1);
32 W23=p2*(V3-V2);

```

```

33 W123=W12+W23;
34
35 //if the above processes are replaced by a single
    reversible polytropic process giving the same
    work between initial and final states ,
36 //W13=W123=(p1V1-p3V3)/(n-1)
37 p3=p2;
38 n=1+(p1*V1-p3*V3)/W123;           //index of expansion
    , n
39
40 printf(' (i) The Total Work done is: %5.0f Nm or J.
    \n',W123);
41 printf(' (ii) The value of index of expansion , n is:
    %1.3f. \n',n);
42
43 //NOTE:
44 //there is slight variation in answers of the book
    due to rounding off of the values

```

---

### Scilab code Exa 3.10 Example 10

```

1  clc
2  clear
3  //DATA GIVEN
4  //initial state
5  p1=10^5;           //initial pressure
    of gas in Pa
6  V1=0.45;           //initial volume of
    gas in m^3
7  T1=80+273;         //initial
    temperature of gas in K
8  //final state
9  p2=5*10^5;         //final pressure of
    gas in Pa
10 V2=0.13;           //final volume of

```

```

        gas in m^3
11
12 //gamma for air , g
13 g=1.4;
14 R=294.2                                //J/kgK
15
16 m=p1*V1/R/T1;                          //mass in kg
17
18 //p1*(V1^n)=p2*(V2^n)
19 n=log(p1/p2)/log(V2/V1);              //index n
20
21 //In a polytropic process
22 //(T2/T1)=(V1/V2)^(n-1);
23 T2=T1*(V1/V2)^(n-1);                  //temp. T2 in K
24
25 Cv=R/(g-1);
26 Du=m*Cv*(T2-T1)/1000;                  //increase in
        internal energy in kJ
27
28 //using First Law of Thermodynamics, Q=(u2-u1)+W
29 //W12=(p1*V1-p2*V2)/(n-1)=mR(T2-T1)/(n-1)
30 W12=m*R*(T1-T2)/(n-1)/1000;
31 Q=Du+W12;
32 //since Q is -ve, there is rejection of heat from
        system to surroundings
33
34 printf(' (i) The Mass of the gas is: %1.3f kg. \n',(
        m));
35 printf(' (ii) The index n is: %1.3f. \n',(n));
36 printf(' (iii) The change in internal energy is: %2.1
        f kJ. \n',(Du));
37 printf(' (iv) The Heat REJECTED is: %2.2f kJ. \n',(-
        Q));

```

---

Scilab code Exa 3.11 Example 11

```

1  clc
2  clear
3  //DATA GIVEN
4  //initial state
5  p1=1.02;                                //initial pressure
    of air in bar
6  V1=0.015;                              //initial volume of
    air in m^3
7  T1=22+273;                             //initial
    temperature of air in K
8  //final state
9  p2=6.8;                                //final pressure of
    air in bar
10 //Law of adiabatic compression,  $pV^g=C$ 
11
12 //gamma for air, g
13 g=1.4
14 R=0.287;
15
16 //In a adiabatic process
17 //  $(T2/T1)=(p2/p1)^{((g-1)/g)}$ ;
18 T2=T1*(p2/p1)^((g-1)/g);              //final temp. T2 in
    K
19
20 //  $p1*(V1^g)=p2*(V2^g)$ 
21 V2=V1*(p1/p2)^(1/g);                  //final volume in m
    ^3
22
23 m=p1*10^5*V1/10^3/R/T1;                //mass in kg
24
25 //  $W=(p1*V1-p2*V2)/(g-1)=mR(T2-T1)/(g-1)$ 
26 W=m*R*(T1-T2)/(g-1);
27 //since W is -ve, the work is done on the air
28
29 printf(' (i) The Final temperature is: %3.2f deg.
    celsius. \n',(T2-273));
30 printf(' (ii) The Final Volume is: %1.5f m^3. \n',V2
    );

```

```

31 printf(' (iii) The Work done on the air is: %1.3 f kJ.
    \n', (-W));

```

---

### Scilab code Exa 3.12 Example 12

```

1  clc
2  clear
3  //DATA GIVEN
4  m=0.44; //mass of air in kg
5  T1=180+273; //initial
    temperature of air in K
6  T2=15+273; //final temperature
    of air in K
7  W12=52.5; //work done during
    the process in kJ
8  //V2/V1=3
9  Vr=3; //volume ratio, Vr=
    V2/V1
10
11 //Law of adiabatic expansion,  $pV^g=C$ 
12
13 //In an adiabatic process
14 //(T2/T1)=(V1/V2)^(g-1);
15 g=1+[(log(T2/T1)/log(1/Vr))]; //gamma
    for air,  $g=C_p/C_v$ 
16
17 //W12=(p1*V1-p2*V2)/(n-1)=mR(T2-T1)/(g-1)
18 R=W12/m/(T1-T2)*(g-1);
19 //R=Cp-Cv
20
21 Cv=R/(g-1);
22 Cp=g*Cv;
23
24 printf(' (i) The value of Cv is: %1.3 f kJ/kgK. \n',
    Cv);

```

```

25 printf(' (ii) The value of Cp is: %1.3f kJ/kgK. \n',
        Cp);
26
27 //NOTE:
28 //there is slight variation in answers of the book
    due to rounding off of the values

```

---

### Scilab code Exa 3.13 Example 13

```

1  clc
2  clear
3  //DATA GIVEN
4  m=1;                                //mass of etahne gas
        in kg
5  M=30;                                //molecular weight
        of ethane
6  p1=1.1;                              //initial pressure
        in bar
7  T1=27+273;                           //initial
        temperature in K
8  p2=6.6;                              //final pressure in
        bar
9  Cp=1.75;                             //in kJ/kgK
10
11 //Law of compression ,  $pV^{1.3}=C$ 
12 n=1.3;
13
14 //Characteristic gas constant , R = Universal gas
        constant (Ro)/Molecular weight(M)
15 Ro=8314;
16 R=Ro/M/1000;                         //kJ/kgK
17
18 //R=Cp-Cv
19 Cv=Cp-R;
20 g=Cp/Cv;                             //gamma g

```

```

21
22 //In a polytropic process
23 // (T2/T1)=(p2/p1)^((n-1)/n);
24 T2=T1*(p2/p1)^((n-1)/n);;           //final temp. T2 in
    K
25
26 //W=(p1*V1-p2*V2)/(n-1)=mR(T2-T1)/(g-1)
27 W=m*R*(T1-T2)/(n-1);
28
29 Q=[(g-n)/(g-1)]*W;                 //heat flow in kJ/kg
30
31 printf(' The Heat SUPPLIED is: %2.1f kJ/kg. \n', (Q))
    ;

```

---

# Chapter 4

## Properties of Steam

Scilab code Exa 4.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  Ms=50;                                //mass of dry steam
    in kg
5  Mw=1.5;                               //mass of water in
    suspension in kg
6
7  //dryness fraction , x=(mass of dry steam)/(mass of
    dry steam +mass of water in suspension)
8  x=Ms/(Ms+Mw);
9
10 printf('The Dryness fraction (Quality) of steam is:
    %1.3 f . ',x);
```

---

Scilab code Exa 4.2 Example 2

```
1  clc
```

```

2  clear
3  //DATA GIVEN
4  V=0.6;                                //volume of the
    vessel in m^3
5  p=0.5;                                //pressure in bar
6  M=3;                                  //mass of liquid and
    water vapour in kg
7
8  v=V/M;                                //specific volume in
    m^3/kg
9  //At 5 bar, from steam tables
10 vg=0.375;                             //m^3/kg
11 vf=0.00109;                           //m^3/kg
12 vfg=vg-vf;
13 //v=vg-(1-x)vfg
14 x=(v-vg)/vfg+1;                       //quality of the
    vapour
15
16 //mass and volume of liquid
17 Mliq=M*(1-x);
18 Vliq=Mliq*vf;
19
20 //mass and volume of vapour
21 Mvap=M*x;
22 Vvap=Mvap*vg;
23
24 printf('(i) The Mass and Volume of liquid is: \n');
25 printf('    Mliq. is: %1.3f kg. \n',Mliq);
26 printf('    Vliq. is: %1.4f m^3. \n',Vliq);
27 printf('(ii) The Mass and Volume of vapour is: \n');
28 printf('    Mvap. is: %1.3f kg. \n',Mvap);
29 printf('    Vvap. is: %1.4f m^3. \n',Vvap);

```

---

Scilab code Exa 4.3 Example 3

```

1  clc
2  clear
3  //DATA GIVEN
4  V=0.05;                                //volume of vessel in
      m^3
5  Mf=10;                                //mass of liquid in
      kg
6  T=245;                                //temp. in deg
      celsius
7
8  //from steam tables , corresponding to 245 deg
      celsius
9  Psat=36.5;                            //bar
10 vf=0.001239;                          //m^3/kg
11 vg=0.0546;                            //m^3/kg
12 hf=1061.4;                            //kJ/kg
13 hfg=1740.2;                           //kJ/kg
14 sf=2.7474;                            //kJ/kgK
15 sfg=3.3585;                           //kJ/kgK
16
17 Vf=Mf*vf;                             //volume of liquid
18 Vg=V-Vf;                              //volume of vapour
19 Mg=Vg/vg;                             //mass of vapour
20 m=Mf+Mg;                              //total mass of
      mixture
21
22 x=Mg/(Mg+Mf);                         //quality of the
      mixture
23 vfg=vg-vf;
24 v=vf+x*vfg;                           //specific volume
25
26 h=hf+x*hfg;                           //specific enthalpy
27
28 s=sf+x*sfg;                           //specific entropy
29
30 u=h-Psat*10^5*v/10^3;                 //specific internal
      energy
31

```

```

32
33 printf(' (i) The Pressure is: %2.1f bar. \n',Psat);
34 printf(' (ii) The mass m is: %2.3f kg. \n',m);
35 printf('(iii) The Specific volume v is: %1.6f m^3/kg
    . \n',v);
36 printf(' (iv) The Specific enthalpy h is: %4.2f kJ/
    kg. \n',h);
37 printf(' (v) The Specific entropy s is: %1.4f kJ/
    kgK. \n',s);
38 printf(' (vi) The Specific internal energy u is: %4
    .2f kJ/kg. \n',u);
39
40 //NOTE:
41 //there is slight variation in answers of book due
    to rounding off of the values in the book

```

---

#### Scilab code Exa 4.4 Example 4

```

1  clc
2  clear
3  //DATA GIVEN
4  Mw=2;                                //mass of water to be
    converted to steam in kg
5  Tw=25;                               //temp. of water in
    deg celsius
6  p=5;                                 //pressure
7  x=0.9;                               //dryness fraction
8
9  //At 5 bar, from steam tables
10 hf=640.1;                            //kJ/kg
11 hfg=2107.4;                           //kJ/kg
12
13 h=hf+x*hfg;                           //specific enthalpy (
    above 0 deg celsius)
14 hs=1*4.18*(Tw-0);                     //sensible heat

```

```

        associated with i kg of water
15 hnet=h-hs;                               //net quantity of
    heat to be supplied per kg of water
16 Htotal=Mw*hnet;                           //total amount of
    heat to be supplied
17
18 printf('The Total amount of heat to be supplied is:
    %4.2f kJ. ',Htotal);

```

---

#### Scilab code Exa 4.5 Example 5

```

1  clc
2  clear
3  //DATA GIVEN
4  m=4.4;                                     //mass of steam to be
    produced in kg
5  p=6;                                       //pressure of steam
6  Tsup=250;                                 //temp. of steam in
    deg. celsius
7  Tw=30;                                    //temp. of water in
    deg celsius
8  Cps=2.2;                                  //specific heat of
    steam in kJ/kg
9
10 //At 6 bar, from steam tables
11 Ts=158.8;                                //deg. celsius
12 hf=670.4;                                //kJ/kg
13 hfg=2085;                                 //kJ/kg
14 //since the given temp. 250 deg celsius is greater
    than 158.8 deg celsius , steam is superheated
15
16 hsup=hf+hfg+Cps*(Tsup-Ts);                //enthalpy of 1 kg
    supergeated steam reckoned from 0 deg. celsius
17 hs=1*4.18*(Tw-0);                         //sensible heat
    associated with i kg of water

```

```

18 hnet=hsup-hs;           //net quantity of
    heat to be supplied per kg of water
19 Htotal=m*hnet;         //total amount of
    heat to be supplied
20
21 printf('The Total amount of heat to be supplied is:
    %4.1f kJ. ',Htotal);

```

---

#### Scilab code Exa 4.6 Example 6

```

1  clc
2  clear
3  //DATA GIVEN
4  V=0.15;                //volume of wet steam
    in m^3
5  p=4;                   //pressure of wet
    steam in bar
6  x=0.8;                 //dryness fraction
7
8  //At 4 bar, from steam tables
9  vg=0.462;              //m^3/kg
10 hf=604.7;              //kJ/kg
11 hfg=2133;              //kJ/kg
12
13 rho=1/(x*vg);           //density in kg/m^3
14 m=rho*V;                //mass of 0.15 m^3 of
    steam
15
16 Htotal=(rho*1)*(hf+x*hfg); //total heat of 1 m^3
    of steam which has a mass of rho(2.7056) kg
17
18 printf('(i)The Mass of 0.15 m^3 of steam is: %1.4f
    kg. \n',m);
19 printf('(ii)The Total heat of 1 m^3 of steam which
    has a mass of 2.7056 kg is: %4.2f kJ. \n',Htotal)

```

;

---

#### Scilab code Exa 4.7 Example 7

```
1  clc
2  clear
3  //DATA GIVEN
4  m=1000;                                //mass of steam
    generated in kg/hr
5  p=16;                                  //pressure of steam
    in bar
6  x=0.9;                                //dryness fraction
7  Tsup=380+273;                          //temp. of
    superheated steam in K
8  Tfw=30;                                //temp. of feed water
    in deg. celsius
9  Cps=2.2;                              //specific heat of
    steam in kJ/kg
10
11 //At 16 bar, from steam tables
12 Ts=201.4+273;                          //in K
13 hf=858.6;                              //kJ/kg
14 hfg=1933.2;                            //kJ/kg
15
16 Hs=m*[(hf+x*hfg)-1*4.187*(Tfw-0)];      //heat
    supplied to feed water per hr to produce wet
    steam
17 Ha=m*[(1-x)*hfg+Cps*(Tsup-Ts)];         //heat
    absorbed by superheater per hour
18
19 printf('(i) The Heat supplied to feed water per hour
    to produce wet steam is: %4.2f*10^3 kJ. \n',(Hs
    /1000));
20 printf('(ii) The Heat absorbed by superheater per
    hour is: %3.2f*10^3 kJ. \n',(Ha/1000));
```

---

Scilab code Exa 4.8 Example 8

```
1  clc
2  clear
3
4  //At 0.75 bar. From steam tables ,
5  //At 100 deg celsius
6  T1=100;                      //deg celsius
7  hsup1=2679.4;                 //kJ/kg
8  //At 150 deg celsius
9  T2=150;                      //deg celsius
10 hsup2=2778.2;                 //kJ/kg
11 Cps1=(hsup2-hsup1)/(T2-T1);
12
13 //At 0.5 bar. From steam tables ,
14 //At 300 deg celsius
15 T3=300;                      //deg celsius
16 hsup3=3075.5;                 //kJ/kg
17 //At 400 deg celsius
18 T4=400;                      //deg celsius
19 hsup4=3278.9;                 //kJ/kg
20 Cps2=(hsup4-hsup3)/(T4-T3);
21
22 printf(' (i) The mean specific heat for superheated
        steam \n      (At 0.75 bar, between 100 and 150
        deg celsius) is: %1.3f. \n',Cps1);
23 printf(' (ii) The mean specific heat for superheated
        steam \n      (At 0.5 bar, between 300 and 400
        deg celsius) is: %1.3f. \n',Cps2);
```

---

Scilab code Exa 4.9 Example 9

```

1  clc
2  clear
3  //DATA GIVEN
4  m=1.5;                                //mass of steam in
    cooker in kg
5  p1=5;                                //pressure of steam
    in bar
6  x1=1;                                //initial dryness
    fraction of steam
7  x2=0.6;                                //final dryness
    fraction of steam
8
9  //At 5 bar, from steam tables
10 Ts1=151.8+273;                        //in K
11 hf1=640.1;                            //kJ/kg
12 hfg1=2107.4;                          //kJ/kg
13 vg1=0.375;                            //m^3/kg
14
15 V1=m*vg1;                             //
    volume of pressure cooker in m^3
16 u1=(hf1+hfg1)-(p1*10^5)*(vg1*10^-3);   //
    internal energy of steam per kg at initial point
    1
17 //V1=V2
18 //V1=m*[(1-x2)*vf2+x2*vg2]           //vf2
    is negligible
19 vg2=V1/x2/1.5;
20
21 //from steam tables coreesponding to vg2=0.625 m^3/
    kg
22 p2=2.9;
23 Ts2=132.4+273;                        //in K
24 hf2=556.5;                            //kJ/kg
25 hfg2=2166.6;                          //kJ/kg
26
27 u2=(hf2+x2*hfg2)-(p2*10^5)*x2*(vg2*10^-3); //
    internal energy of steam per kg at final point 2
28

```

```

29 hnet=u2-u1;                                //heat
    transferred at constant volume per kg
30 Htotal=m*hnet;                              //
    total heat transferred
31 //-ve sign indicates that heat has been rejected
32 Hrej=-1*Htotal;
33
34 printf(' (i) The Pressure at new state is: %1.1f bar
    . \n',p2);
35 printf('          The Temperature at new state is: %3.1f
    deg. celsius or %3.1f K. \n',(Ts2-273),Ts2);
36 printf(' (ii) The Total heat to be REJECTED is: %4.2
    f kJ. ',Hrej);

```

---

#### Scilab code Exa 4.10 Example 10

```

1  clc
2  clear
3  //DATA GIVEN
4  V=0.9;                                     //capacity of
    spherical vessel in m^3
5  p1=8;                                     //pressure of steam
    in bar
6  x1=0.9;                                   //dryness fraction
    of steam
7  p2=4;                                     //pressure of steam
    after blow off in bar
8  p3=3;                                     //final pressure of
    steam in bar
9
10 //At 8 bar, from steam tables
11 hf1=720.9;                               //kJ/kg
12 hfg1=2046.5;                             //kJ/kg
13 vg1=0.240;                               //m^3/kg
14

```

```

15 m1=V/(x1*vg1); //mass of steam in
    the vessel in kg
16
17 h1=hf1+x1*hfg1; //enthalpy of steam
    before blowing off (per kg)
18 //enthalpy of steam before blowing off (per kg) =
    enthalpy of steam after blowing off (per kg)
19 h2=h1;
20 //h2=hf2+x2*hfg2
21 //At 4 bar, from steam tables
22 hf2=604.7; //kJ/kg
23 hfg2=2133; //kJ/kg
24 vg2=0.462; //m^3/kg
25 x2=(h2-hf2)/hfg2; //dryness fraction
    at 2
26
27 m2=V/(x2*vg2); //mass of steam in
    the vessel in kg
28 m=m1-m2; //mass of steam
    blown off in kg
29
30 //As it is constant volume cooling, x2*vg2(at 4 bar)
    =x3*vg3(at 3 bar)
31 //At 3 bar, from steam tables
32 hf3=561.4; //kJ/kg
33 hfg3=2163.2; //kJ/kg
34 vg3=0.606; //m^3/kg
35
36 x3=x2*vg2/vg3;
37 h3=hf3+x3*hfg3;
38
39 //heat lost during cooling, Qlost=m(u3-u2)
40 u2=h2-p2*10^5*x2*vg2*10^-3;
41 u3=h3-p3*10^5*x3*vg3*10^-3;
42 Qlost=m*(u3-u2);
43
44 printf(' (i) The Mass of of steam blown off is: %1.3
    f kg. \n',m);

```

```

45 printf(' (ii) The Dryness fraction of steam in the
    vessel after cooling is: %1.4f. \n',x3);
46 printf('(iii) The Heat lost during cooling is: %3.2f
    kJ. \n',(-Qlost));
47
48 //NOTE:
49 //The answers of m1,x3 are INCORRECT in the book,
50 //thus, the answers of m, x3 and Qlost are INCORRECT
    in the book
51 //while, the values obtained her (in scilab) are
    CORRECT.

```

---

#### Scilab code Exa 4.11 Example 11

```

1  clc
2  clear
3  //DATA GIVEN
4  p=8;                                //pressure of steam
    in bar
5  x=0.8;                              //dryness fraction
6
7  //At 8 bar, from steam tables
8  vg=0.240;                           //m^3/kg
9  hfg=2046.5;                         //kJ/kg
10
11 We=p*10^5*x*vg/1000;                //external work done
    during evaporation in kJ
12 LHi=x*hfg-We;                      //Internal latent
    heat in kJ
13
14 printf(' (i) The External work done during
    evaporation is: %3.1f kJ. \n',We);
15 printf(' (ii) The Internal latent heat is: %4.1f kJ.
    \n',LHi);

```

---

# Scilab code Exa 4.12 Example 12

```

1  clc
2  clear
3  //DATA GIVEN
4  p=10;                                //pressure of steam,
    p1=p2 in bar
5  x1=0.85;                            //dryness fraction
6  V1=0.15;                            //volume of steam in
    m^3
7  Tsup2=300+273;                      //temp. of steam in K
8  Cps=2.2;                            //specific heat of
    steam in kJ/kgK
9
10 //At 10 bar, from steam tables
11 vg1=0.194;                          //m^3/kg
12 hfg1=2013.6;                        //kJ/kg
13 Ts1=179.9+273;                      //in K
14 m=V1/(x1*vg1);                      //mass of steam
    in kg
15 hnet=(1-x1)*hfg1+Cps*(Tsup2-Ts1);    //heat supplied
    per kg of steam
16 Htotal=m*hnet;                      //total heat
    supplied
17
18 //External work done during the process We=p*(vsup2-
    x*vg1)
19 //since p1=p2=p,
20 //vg1/Ts1=vsup2/Tsup2
21 vsup2=vg1*Tsup2/Ts1;
22 We=p*10^5*(vsup2-x1*vg1)*10^-3;
23 hp=We/hnet;                          // % of total
    heat supplied (per kg) which appears as external
    work

```

```

24
25 printf(' (i) The Total heat supplied is: %3.1f kJ. \
    n',Htotal);
26 printf(' (ii) The Percentage of total heat supplied
    (per kg) which appears as external work is: %2.1f
    percent. \n',(hp*100));

```

---

### Scilab code Exa 4.13 Example 13

```

1  clc
2  clear
3  //DATA GIVEN
4  p=18;                                //pressure of steam
5  x=0.85;                              //dryness fraction
6
7  //At 18 bar, from steam tables
8  hf=884.6;                            //kJ/kg
9  hfg=1910.3;                          //kJ/kg
10 vg=0.110;                            //m^3/kg
11 uf=883;                              //kJ/kg
12 ug=2598;                             //kJ/kg
13
14 v=x*vg;                              //specific volume of
    wet steam
15 h=hf+x*hfg;                          //specific enthalpy
    of wet steam
16 u=(1-x)*uf+x*ug;                    //specific internal
    energy of wet steam
17
18 printf(' (i) The Specific volume v is: %1.4f m^3/kg.
    \n',v);
19 printf(' (ii) The Specific enthalpy h is: %4.2f kJ/
    kg. \n',h);
20 printf(' (iii) The Specific internal energy u is: %4
    .2f kJ/kg. \n',u);

```

---

Scilab code Exa 4.14 Example 14

```
1  clc
2  clear
3  //DATA GIVEN
4  p=7;                                //pressure of steam
5  h=2550;                             //enthalpy of steam
6
7  //At 7 bar, from steam tables
8  hf=697.1;                           //kJ/kg
9  hfg=2064.9;                         //kJ/kg
10 vg=0.273;                          //m3/kg
11 uf=696;                             //kJ/kg
12 ug=2573;                            //kJ/kg
13
14 hg=hf+hfg;
15 //At 7 bar, hg=2762 kJ/kg, hence since actual
    enthalpy is given as 2550 kJ/kg, the steam must
    be in wet vapour state
16 //specific enthalpy of wet steam, h=hf+x*hfg
17 x=(h-hf)/hfg;                       //dryness fraction
18 v=x*vg;                             //specific volume of
    wet steam
19 u=(1-x)*uf+x*ug;                   //specific internal
    energy of wet steam
20
21 printf(' (i) The Dryness fraction x is: %1.3f. \n',x
    );
22 printf(' (ii) The Specific volume v is: %1.4f m3/kg
    . \n',v);
23 printf(' (iii) The Specific internal energy u is: %4
    .2f kJ/kg. \n',u);
```

---

#### Scilab code Exa 4.15 Example 15

```
1  clc
2  clear
3  //DATA GIVEN
4  p=120;                                //pressure of steam
5  v=0.01721;                            //specific volume of
    steam
6
7  //At 120 bar, from steam tables
8  vg=0.0143;                            //m^3/kg
9  //since vg<v, the steam is superheated
10 //so from superheat tables at 120 bar and v=0.01721
    m^3/kg
11 T=350;                                //deg. celsius
12 h=2847.7;                             //specific enthalpy
    of steam
13 u=h-p*10^5*v/10^3;                    //specific internal
    energy of steam
14
15 printf(' (i) The Temperature is: %3.0f deg celsius.\n',T);
16 printf(' (ii) The Specific enthalpy h is: %4.1f kJ/kg.\n',h);
17 printf(' (iii) The Specific internal energy u is: %4.2f kJ/kg.\n',u);
```

---

#### Scilab code Exa 4.16 Example 16

```
1  clc
2  clear
3  //DATA GIVEN
```

```

4  p=140;                                //pressure of steam
5  h=3001.9;                             //specific enthalpy
    of steam
6
7  //At 140 bar, from steam tables
8  hg=2642.4;
9  //since hg<h, the steam is superheated
10 //so from superheat tables at 140 bar and h=3001.9
    kJ/kg
11 T=400;                                //deg. celsius
12 v=0.01722;                             //specific volume of
    steam
13 u=h-p*105*v/103;                     //specific internal
    energy of steam
14
15 printf(' (i) The Temperature is: %3.0f deg celsius.
    \n',T);
16 printf(' (ii) The Specific volume v is: %1.5f m3/kg
    . \n',v);
17 printf('(iii) The Specific internal energy u is: %4
    .2f kJ/kg. \n',u);

```

---

#### Scilab code Exa 4.17 Example 17

```

1  clc
2  clear
3
4  p1=10;                                //pressure in
    bar
5  //At 10 bar and 300 deg celsius , from steam tables
    of superheated steam
6  hsup=3051.2                            //kJ/kg
7  Tsup=300+273;                          //temp. of steam
    in K
8  //At 10 bar and 300 deg celsius , from steam tables

```

```

        of dry saturated steam
9  Ts=179.9+273                                //temp. of steam
        in K
10  vg=0.194;                                //m^3/kg
11
12  //By  $vg/Ts = v_{sup}/T_{sup}$ 
13  vsup=vg*Tsup/Ts;
14  u1=hsup-p1*10^5*vsup/10^3;
15
16  p2=1.4;                                //new pressure
        in bar
17  x2=0.8;                                //dryness
        fraction
18  //At 1.4 bar, from steam tables
19  hf2=458.4;                                //kJ/kg
20  hfg2=2231.9;                            //kJ/kg
21  vg2=1.236;                            //m^3/kg
22  h2=hf2+x2*hfg2;                        //enthalpy of
        wet steam (after expansion)
23  u2=h2-p2*10^5*x2*vg2/10^3;            //internal
        energy of this steam
24  Du=u2-u1;                                //change in
        internal energy per kg
25
26  printf(' (i) The Internal energy of superheated
        steam at 10 bar is: %4.1f kJ/kg. \n',u1);
27  printf(' (ii) The Change in internal energy per kg
        is: %2.1f kJ. \n',Du);
28  printf('      (Negative sign indicates DECREASE in
        internal energy.) ');

```

---

#### Scilab code Exa 4.18 Example 18

```

1  clc
2  clear

```

```

3 //DATA GIVEN
4 m=1; //mass of steam in kg
5 p=20; //pressure of steam
    in bar
6 Tsup=400+273; //temp. of steam in K
7 x=0.9; //dryness fraction
8 Cps=2.3; //specific heat of
    steam in kJ/kgK
9
10 //At 20 bar, from steam tables
11 Ts=212.4+273; //in K
12 hf=908.6; //kJ/kg
13 hfg=1888.6; //kJ/kg
14 vg=0.0995; //m^3/kg
15 hsup=hf+hfg+Cps*(Tsup-Ts); //kJ/kg
16
17 //Assume superheated steam to behave as a perfect
    gas from the commencement of superheating and
    thus obey Charle's Law
18 //By  $vg/Ts=vsup/Tsup$ 
19 vsup=vg*Tsup/Ts;
20 usup=hsup-p*10^5*vsup*10^-3; //internal
    energy of 1 kg of superheated steam in kJ/kg
21
22 h=hf+x*hfg;
23 u=h-p*10^5*x*vg*10^-3; //internal
    energy of 1 kg of wet steam in kJ/kg
24
25 printf('(i) The Internal energy of 1 kg of
    superheated steam at 400 deg celsius is: %4.2f kJ
    /kg. \n',usup);
26 printf('(ii) The Internal energy of 1 kg of wet
    steam with dryness fraction 0.9 is: %4.2f kJ/kg.
    \n',u);

```

---

### Scilab code Exa 4.19 Example 19

```
1  clc
2  clear
3  //DATA GIVEN
4  p=20;                                //pressure in the
    boilers and main is 20 bar
5  Tbs=350;                            //temperature of steam
    in boiler with superheater in deg. celsius
6  Tm=250;                            //temperature of steam
    in the main in deg. celsius
7  Cps=2.25;                          //specific heat of
    steam in kJ/kg
8
9  //At 20 bar, from steam tables
10 Ts=212.4;                          //deg. celsius
11 hf=908.6;                          //kJ/kg
12 hg=2797.2;                         //kJ/kg
13 hfg=1888.6;                        //kJ/kg
14
15 //Boiler B1-20 bar, 350 deg. celsius
16 h1=hg+Cps*(Tbs-Ts);
17
18 //Main-20 bar, 250deg celsius
19 hm=2*[hg+Cps*(Tm-Ts)];              //total heat of
    2 kg of steam in the steam main
20
21 //Boiler B2-20 bar,
22 //h2=hf+x2*hfg
23 //h2=hm-h1
24 x2=((hm-h1)-hf)/hfg;
25
26 printf('The Quality of steam in the Boiler without
    superheater is: %1.3f. \n',x2);
```

---

#### Scilab code Exa 4.20 Example 20

```
1  clc
2  clear
3  //DATA GIVEN
4  m=1;                                //mass of wet
    steam in kg
5  p=6;                                //pressure of
    steam in bar
6  x=0.8;                              //dryness
    fraction
7
8  //At 6 bar, from steam tables
9  Ts=158.8+273;                       //in K
10 hfg=2085;                           //kJ/kg
11 swet=4.18*log(Ts/273)+x*hfg/Ts;      //entropy of
    wet steam in kJ/kgK
12
13 printf('The Entropy of wet steam is: %1.4f kJ/kgK.',
    swet);
14
15 //NOTE;
16 //the exact ans is 5.7794, while in TB it is given
    as 5.7865 kJ/kgK
```

---

#### Scilab code Exa 4.21 Example 21

```
1  clc
2  clear
3  //DATA GIVEN
4  p1=10;                              //initial pressure of
    steam in bar
5  Tsup=250;                           //initial temperature
    of steam in deg celsius
6  p2=0.2;                             //final pressure of
```

```

    steam in bar
7  x2=0.9;                                //final dryness
    fraction of steam
8
9  //At 10 bar, from steam tables
10 hsup=3263.9;                          //kJ/kg
11 ssup=7.465;                            //kJ/kgK
12 h1=hsup;
13 s1=ssup;
14
15 //At 0.2 bar, from steam tables
16 hf2=251.5;                            //kJ/kg
17 hfg2=2358.4;                          //kJ/kg
18 sf2=0.8321;                           //kJ/kgK
19 sg2=7.9094;                           //kJ/kgK
20 h2=hf2+x2*hfg2;
21 sfg2=(sg2-sf2);
22 s2=sf2+x2*sfg2;
23
24 Dh=h1-h2;                             //drop in enthalpy
25 Ds=s1-s2;                             //change in entropy
26
27 printf(' (i) The Drop in enthalpy is: %3.1f kJ/kg. \
    n',Dh);
28 printf(' (ii) The change (DECREASE) in entropy is:
    %1.4f kJ/kgK. ',Ds);

```

---

#### Scilab code Exa 4.22 Example 22

```

1  clc
2  clear
3  //DATA GIVEN
4  m=1;                                //mass of steam in kg
5  p=12;                               //pressure of steam
    in bar

```

```

6  Tsup=250+273;           //temp. of steam in K
7  Cps=2.1;               //specific heat of
    steam in kJ/kg
8
9  //At 12 bar, from steam tables
10 Ts=188+273;            //in K
11 hfg=1984.3;            //kJ/kg
12 ssup=4.18*log(Ts/273)+hfg/Ts+Cps*log(Tsup/Ts);
    //entropy of wet steam in kJ/kgK
13
14 printf(' The Entropy of 1 kg of superheated steam at
    12 bar and 250 deg celsius is: %1.3f kJ/kg. \n',
    ssup);

```

---

#### Scilab code Exa 4.23 Example 23

```

1  clc
2  clear
3  //DATA GIVEN
4  p=5;                   //pressure of steam
    in bar
5  Mwt=50;                //mass of water in
    the tank in kg
6  t1=20;                 //initial temp. in
    deg. celsius
7  Ms=3;                  //amount of steam
    condensed in kg
8  t2=40;                 //final temp. in deg.
    celsius
9  We=1.5;                //water equivalent of
    tank in kg
10
11 //At 5 bar, from steam tables
12 hf=640.1;              //in kJ/kg
13 hfg=2107.4;            //in kJ/kg

```

```

14
15 Mw=Mwt+We;                                //total mass of water
    in kg
16 //heat lost by steam = heat gained by water
17 //Ms[( hf+xhfg) -1*4.18*(t2-0)]=Mw[1*4.18*(t2-t1)]
18 x=[Mw*[1*4.18*(t2-t1)]/Ms+1*4.18*(t2-0)-hf]/hfg;
    //dryness fraction
19
20 printf('The Dryness fraction of steam, x is: %1.4f.',
    ,x);

```

---

#### Scilab code Exa 4.24 Example 24

```

1  clc
2  clear
3  //DATA GIVEN
4  p=1.1;                                    //pressure of steam
    in bar
5  x=0.95;                                    //dryness fraction
6  Mwt=90;                                    //mass of water in
    the tank in kg
7  t1=25;                                    //initial temp. in
    deg. celsius
8  Mt=12.5;                                    //mass of tank in kg
9  c=0.42;                                    //specific heat of
    metal in kJ/kgK
10 t2=40;                                    //final temp. in deg.
    celsius
11
12 m1=Mwt;
13 m2=Mt*c;                                    //water equivalent of
    vessel
14 M=m1+m2;                                    //total mass of water
    in kg
15 //At 1.1 bar, from steam tables

```

```

16 hf=428.8;                                //in kJ/kg
17 hfg=2250.8;                              //in kJ/kg
18 //heat lost by steam = heat gained by water
19 //Ms[( hf+xhfg) -1*4.18*(t2-0)]=M[1*4.18*(t2-t1)]
20 Ms=M*[1*4.18*(t2-t1)]/[(hf+x*hfg) -1*4.18*(t2-0)];
    //mass of steam condensed in kg
21
22 printf(' The Mass of steam condensed , Ms is: %1.3 f
    kg. ',Ms);

```

---

#### Scilab code Exa 4.25 Example 25

```

1  clc
2  clear
3  //DATA GIVEN
4  //condition of steam before throttling
5  p1=8;                                //pressure in bar
6  //condition of steam after throttling
7  p2=1;                                //pressure in bar
8  T2=115+273;                          //temp. in deg. celsius
9  Tsup2=T2;
10 //At 1 bar ,
11 Ts2=99.6+273;
12 Cps=2.1;                             //kJ/kgK
13
14 //As throttling is a constant enthalpy process ,
15 //h1=h2..... hf1+x1*hgf1=hf2+hfg2+Cps(Tsup2-Ts2)
16
17 //At 8 bar , from steam tables ,
18 hf1=720.9;
19 hfg1=2046.5;
20 //At 1 bar , from steam tables ,
21 hf2=417.5;
22 hfg2=2257.9;
23

```

```

24 x1=[hf2+hfg2+Cps*(Tsup2-Ts2)-hf1]/hfg1;           //
    dryness fraction
25
26 printf('The Dryness fraction of steam in the main,
    x1 is: %1.2f.',x1);

```

---

#### Scilab code Exa 4.26 Example 26

```

1  clc
2  clear
3  //DATA GIVEN
4  Mw=2;                                     //mass of water
    separated out in kg
5  Ms=20.5;                                 //amount of steam (
    condensate) discharged from throttling
    calorimeter in kg
6  Tsup3=110+273;                           //temp. of steam
    afetr throttling in K
7  p1=12;                                    //initial pressure
    of steam in bar
8  p3=(760+5)/1000*1.3366;                  //final pressure of
    steam in bar (1 mm of Hg=1.3366 bar)
9  Cps=2.1;                                 //kJ/kgK
10
11 p2=p1;
12 //At p1=p2=12 bar, from steam tables
13 hf2=798.4;                               //in kJ/kg
14 hfg2=1984.3;                             //in kJ/kg
15
16 //At p3=1 bar, from steam tables
17 Ts3=99.6+273;                           //in K
18 Tsup3=110+273;                           //in K
19 hf3=417.5;                               //in kJ/kg
20 hfg3=2257.9;                             //in kJ/kg
21

```

```

22 //h2=h3 . . . . . hf2+x2*hgf2=hf3+hfg3+Cps(Tsup3-Ts3)
23 x2=[hf3+hfg3+Cps*(Tsup3-Ts3)-hf2]/hfg2;           //
    dryness fraction x2
24
25 x1=(x2*Ms)/(Mw+Ms);                               //
    dryness fraction of steam supplied, x1
26
27 printf('The Quality of steam supplied, x1 is: %1.2f.
    ',x1);

```

---

#### Scilab code Exa 4.27 Example 27

```

1  clc
2  clear
3  //DATA GIVEN
4  p1=15;                                              //pressure of steam
    sample in bar
5  p3=1;                                              //pressure of steam
    at exit in bar
6  Tsup3=150+273;                                    //temperature os
    steam at the exit in K
7  Mw=0.5;                                           //discharge from
    separating calorimeter in kg/min
8  Ms=10;                                           //discharge from
    throttling calorimeter in kg/min
9
10 p2=p1;
11 //At p1=p2=15 bar, from steam tables
12 hf2=844.7;                                       //in kJ/kg
13 hfg2=1945.2;                                    //in kJ/kg
14
15 //At p3=1 bar and 150 deg. celsius, from steam
    tables
16 hsup3=2776.4;                                    //in kJ/kg
17

```

```

18 //h2=h3 . . . . . hf2+x2*hgf2=hsup3
19 x2=[hsup3-hf2]/hfg2;           //dryness fraction
    x2
20
21 x1=(x2*Ms)/(Mw+Ms);           //quality of steam
    supplied , x1
22
23 printf('The Quality of steam supplied , x1 is: %1.3f.
    ',x1);

```

---

# Chapter 5

## Heat Engines

Scilab code Exa 5.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  Ms=10000/3600;    //rate of steam flow in kg/s
5  //inlet to turbine
6  p1=60;            //pressue in bar
7  T1=380;           //temp. in deg.celsius
8
9  //exit from turbine , inlet to condenser
10 p2=0.1;           //pressue in bar
11 x2=0.9;           //quality
12 v2=200;           //velocity in m/s
13
14 //exit from condenser , inlet to pump
15 p3=0.09;          //pressue in bar
16 //it is saturated
17
18 //exit from pump, inlet to boiler
19 p4=70;             //pressue in bar
20
21 //exit from boiler ,
```

```

22 p5=65;           //pressue in bar
23 T5=400;          //temp. in deg.celsius
24
25 //for condenser,
26 t1=20;           //inlet temp. in deg. celsius
27 t2=30;           //exit temp. in deg. celsius
28
29 //At 60 bar and 380deg. celsius, from steam tables
30 h1=3043.0+(3177.2-3043.0)/(400-350)*30; //By
    interpolation
31
32 //At 0.1 bar, from steam tables
33 hf2=191.8;        //in kJ/kg
34 hfg2=2392.8;      //in kJ/kg
35 h2=hf2+x2*hfg2;
36 Pt=Ms*(h1-h2)     //power output of
    the turbine in kW
37
38 //At 70 bar, from steam tables
39 hf4=1267.4;        //in kJ/kg
40 //At 60 bar and 380deg. celsius, from steam tables
41 ha=(3177.2+3158.1)/2; //By interpolation
    between 60 and 70 deg celsius
42 Q1=Ms*3600*(ha-hf4); //heat transfer
    per hour in the boiler
43 //At 0.09 bar, from steam tables
44 hf3=183.3;        //in kJ/kg
45 Q2=Ms*3600*(h2-hf3); //heat transfer
    per hour in the condenser
46
47 //heat lost by steam=heat gained by the cooling
    water
48 //Q2=Mw*4.18*(t2-t1)
49 Mw=Q2/4.18/10;    //mass of cooling
    water circuleted per hour in condenser
50
51 //(pi)/4*d^2=Ms*x2*vg2
52 //d=diameter of the pipe connecting turbine with

```

```

condenser
53 C=200;                                //velocity of
    steam in m/s
54 vg2=14.67;                            //specific volume
    at 0.1 bar
55 d=(Ms*x2*vg2/((%pi/4)/C)^0.5;
56
57 printf(' (i) The Power output of turbine is: %4.0f
    kW. \n',Pt);
58 printf(' (ii) The Heat transfer per hour in the
    Boiler is: %3.2e kJ/h. \n',Q1);
59 printf('      The Heat transfer per hour in the
    Condenser is: %3.2e kJ/h. \n',Q2);
60 printf('(iii) The Mass of cooling water circulated
    per hour in the condenser is: %3.2e kg/hr. \n',Mw
    );
61 printf(' (iv) The Diameter of the pipe connecting
    turbine with condenser is: %1.3f m or %3.0f mm. \
    n',d,(d*1000));
62
63 //NOTE:
64 //ans of Mw(1.116*10^7) is given incorrect in the
    book.
65 //the correct ans of Mw is = 5.17*10^5 kg/h.

```

---

#### Scilab code Exa 5.2 Example 2

```

1 clc
2 clear
3 //DATA GIVEN
4 p1=15;                                //steam supply pressure in
    bar
5 x1=1;                                //quality of steam
6 p2=0.4;                              //condenser pressure
7

```

```

8 //At 0.15 bar, from steam tables
9 T1=198.3+273;           //in K
10 hg1=2789.9;            //in kJ/kg
11 sg1=6.4406;            //in kJ/kgK
12 //At 0.4 bar, from steam tables
13 T2=75.9+273;           //in K
14 hf2=317.7;             //in kJ/kg
15 hfg2=2319.2;           //in kJ/kg
16 sf2=1.0261;            //in kJ/kgK
17 sfg2=6.6448;           //in kJ/kgK
18
19 ETAcarnot=(T1-T2)/T1;   //Carnot efficiency
20 //ETArankine=Adiabatic or isentropic heat drop/heat
    supplied
21 //ETArankine=(hg1-h2)/(hg1-hf2)
22 //as the steam expands isentropically, s1=s2
23 //sg1=sf2+x2*sfg2
24 x2=(sg1-sf2)/sfg2;
25 h2=hf2+x2*hfg2;
26 ETArankine=(hg1-h2)/(hg1-hf2);           //Rankine
    efficiency
27
28 printf(' (i) The Carnot efficiency is: %1.4f or %2.2
    f percent. \n',ETAcarnot,(ETAcarnot*100));
29 printf(' (ii) The Rankine efficiency is: %1.4f or %2
    .2f percent. \n',ETArankine,(ETArankine*100));

```

---

### Scilab code Exa 5.3 Example 3

```

1 clc
2 clear
3 //DATA GIVEN
4 p1=20;           //boiler pressure in bar
5 T1=360+273;      //temp. in K
6 p2=0.08;         //boiler pressure in bar

```

```

7
8 //At 20 bar and 360 deg.celsius , from steam tables
9 h1=3159.3; //in kJ/kg
10 sg1=6.9917; //in kJ/kgK
11
12 //At 0.08 bar , from steam tables
13 hf2=173.88; //in kJ/kg
14 hf3=hf2;
15 sf2=0.5926; //in kJ/kgK
16 s3=sf2;
17 hfg2=2403.1; //in kJ/kg
18 sg2=8.2287; //in kJ/kgK
19 vf2=0.001008; //m^3/kg
20 sfg2=7.6361; //in kJ/kgK
21
22 //as the steam expands isentropically , s1=s2
23 //sg1=sf2+x2*sfg2
24 x2=(sg1-sf2)/sfg2;
25 h2=hf2+x2*hfg2;
26
27 //Wnet=Wturbine-Wpump
28 //Wpump=hf4-hf3=vf3(p1-p2)
29 Wp=vf2*(p1-p2)*100;
30 hf4=Wp+hf3;
31 Wt=h1-h2;
32 Wnet=Wt-Wp;
33 Q1=h1-hf4; //in kJ/kg
34 ETAcycle=Wnet/Q1; //cycle efficiency
35
36 printf(' (i) The Net work per kg of steam is: %3.2f
kJ/kg. \n',Wnet);
37 printf(' (ii) The Cycle efficiency is: %1.3f or %2.1
f percent. \n',ETAcycle,(ETAcycle*100));

```

---

Scilab code Exa 5.4 Example 4

```

1  clc
2  clear
3  //given steam table extract
4  p1=80; //in bar
5  t1=295.1; //in deg. celsius
6  vf1=0.001385; //m^3/kg
7  vg1=0.0235; //m^3/kg
8  hf1=1317; //in kJ/kg
9  hfg1=1440.5; //in kJ/kg
10 hg1=2757.5; //in kJ/kg
11 sf1=3.2073; //in kJ/kgK
12 sfg1=2.5351; //in kJ/kgK
13 sg1=5.7424; //in kJ/kgK
14
15 p2=0.1; //in bar
16 t2=45.84; //in deg. celsius
17 vf2=0.0010103; //m^3/kg
18 vg2=14.68 //m^3/kg
19 hf2=191.9; //in kJ/kg
20 hf3=hf2;
21 hfg2=2392.3; //in kJ/kg
22 hg2=2584.2; //in kJ/kg
23 sf2=0.6488; //in kJ/kgK
24 sfg2=7.5006; //in kJ/kgK
25 sg2=8.1494; //in kJ/kgK
26
27 ETAt=0.9; //steam turbine efficiency
28 ETAp=0.8; //condensate pump
    efficiency
29
30 P1=80; //in bar
31 T1=600; //in deg celsius
32 //At 80 bar and 600 deg celsius
33 v1=0.486; //m^3/kg
34 h1=3642; //kJ/kg
35 s1=7.0206; //kJ/kg/K
36
37 //as the steam expands isentropically , s1=s2

```

```

38 //sg1=sf2+x2*sfg2
39 x2=(s1-sf2)/sfg2;
40 h2=hf2+x2*hfg2;
41 Wta=ETAt*(h1-h2);           //actual turbine work in kJ
    /kg
42 Wp=vf2*(p1-p2)*10^5/10^3; //pump work in kJ/kg
43 Wpa=Wp/ETAp;               //actual pump work in kJ/kg
44 Wnet=Wta-Wpa;               //specific work in kJ/kg
45 //ETAthermal=Wnet/Q1
46 //Q1=h1-hf4
47 hf4=hf3+Wpa;
48 Q1=h1-hf4;
49 ETAth=Wnet/Q1;
50
51 printf(' (i) The Specific work (Wnet) is: %4.2f kJ/
    kg. \n',Wnet);
52 printf(' (ii) The Thermal efficiency is: %1.3f or %2
    .1f percent. \n',ETAth,(ETAth*100));

```

---

#### Scilab code Exa 5.5 Example 5

```

1  clc
2  clear
3  //DATA GIVEN
4  p1=28;           //pressure at 1 in bar
5  p2=0.06;         //pressure at 2 in bar
6
7  //At 28 bar, from steam tables
8  h1=2802;         //in kJ/kg
9  s1=6.2104;       //in kJ/kgK
10
11 //At 0.06 bar, from steam tables
12 hf2=151.5;       //in kJ/kg
13 hf3=hf2;
14 hfg2=2415.9;     //in kJ/kg

```

```

15 sf2=0.521; //in kJ/kgK
16 sf3=sf2;
17 sfg2=7.809; //in kJ/kgK
18 vf2=0.001; //m^3/kg
19
20
21 //as the steam expands isentropically , s1=s2
22 //sg1=sf2+x2*sfg2
23 x2=(s1-sf2)/sfg2;
24 h2=hf2+x2*hfg2;
25
26 //Wnet=Wturbine-Wpump
27 //Wpump=hf4-hf3=vf3(p1-p2)
28 Wp=vf2*(p1-p2)*10^5/10^3;
29 hf4=Wp+hf2;
30 Wt=h1-h2;
31 Wnet=Wt-Wp;
32 Q1=h1-hf4; //in kJ/kg
33 ETAcycle=Wnet/Q1; //cycle efficiency
34 wr=Wnet/Wt; //work ratio
35 ssc=3600/Wnet; //specific steam consumption
    in kg/kWh
36
37 printf(' (i) The Cycle efficiency is: %1.4f or %2.2f
    percent. \n',ETAcycle,(ETAcycle*100));
38 printf(' (ii) The Work ratio is: %1.3f kJ/kg. \n',wr
    );
39 printf('(iii) The Specific steam consumption in kg/
    kWh is: %1.3f kg/kWh. \n',ssc);

```

---

#### Scilab code Exa 5.6 Example 6

```

1 clc
2 clear
3 //DATA GIVEN

```

```

4  p1=35;                                //pressure at inlet to
    turbine in bar
5  x1=1;
6  p2=0.2;                                //pressure at exhaust in bar
7  m=9.5;                                //flow rate in kg/s
8
9  //At 35 bar , from steam tables
10 hg1=2802;                              //in kJ/kg
11 h1=hg1;
12 sg1=6.1228;                            //in kJ/kgK
13
14 //At 0.2 bar , from steam tables
15 hf2=251.5;                              //in kJ/kg
16 hf3=hf2;
17 hfg2=2358.4;                            //in kJ/kg
18 vf2=0.001017;                          //m^3/kg
19 sf2=0.8321;                            //in kJ/kgK
20 sfg2=7.0773;                            //in kJ/kgK
21
22 //Wnet=Wturbine-Wpump
23 //Wpump=hf4-hf3=vf3 (p1-p2)
24 Wp=vf2*(p1-p2)*10^5/10^3;
25 Wpnet=m*Wp;
26 hf4=Wp+hf3;
27
28 //as the steam expands isentropically , s1=s2
29 //sg1=sf2+x2*sfg2
30 x2=(sg1-sf2)/sfg2;                      //dryness
    fraction
31 h2=hf2+x2*hfg2;
32 Wt=h1-h2;
33 Wtnet=m*Wt;
34 ETArankine=(h1-h2)/(h1-hf2);             //Rankine
    efficiency
35 chf=m*(h2-hf3);                         //condenser
    heat flow
36
37 printf(' (i) The Pump Work is: %2.2f kW. \n',Wpnet);

```

```

38 printf(' (ii) The Turbine Work is: %2.2f kW. \n',
    Wtnet);
39 printf('(iii) The Rankine efficiency is: %1.4f or %2
    .2f percent. \n',ETArankine,(ETArankine*100));
40 printf(' (iv) The Condenser heat flow is: %1.3f kW.
    \n',chf);
41 printf(' (v) The dryness at the end of expansion,
    x2 is: %1.3f or %2.1f percent. \n',x2,(x2*100));
42
43 //NOTE:
44 //The value of x2 in the book is given as 0.7470
45 //while the exact ans is 0.74755
46 //and so the values of other answers are varying by
    some units

```

---

#### Scilab code Exa 5.7 Example 7

```

1  clc
2  clear
3  //DATA GIVEN
4  h12=840; //Adiabatic enthalpy drop, (
    h1-h2) in kJ/kg
5  h1=2940; //enthalpy of steam supplied
    in kJ/kg
6  p2=0.1; //back pressure in bar
7
8  //At 0.1 bar, from steam tables
9  hf=191.8; //in kJ/kg
10 //ETArankine=(hg1-h2)/(hg1-hf2)
11 ETArankine=(h12)/(h1-hf);
12 Wuse=h12; //useful work done per kg of
    steam in kJ/kg
13 ssc=1/Wuse*3600; //specific steam consumption
14
15 printf('(i) The Rankine efficiency is: %1.4f or %2.2

```

```

        f percent. \n',ETArankine,(ETArankine*100));
16 printf('(ii) The Specific steam consumption is: %1.3
        f kg/kWh. \n',ssc);

```

---

#### Scilab code Exa 5.8 Example 8

```

1  clc
2  clear
3  //DATA GIVEN
4  IP=35;                                //power developed by the
        engine in kW
5  m=284;                                //flow rate in kg/h
6  p1=15;                                //steam inlet pressure in
        bar
7  p2=0.14;                              //condenser pressure in bar
8
9  //At 35 bar and 25 deg celsius from steam tables
10 h1=2923.3;                            //in kJ/kg
11 s1=6.709;                             //in kJ/kgK
12
13 //At 0.14 bar, from steam tables
14 hf2=220;                              //in kJ/kg
15 hf3=hf2;
16 hfg2=2376.6;                          //in kJ/kg
17 sf2=0.737;                            //in kJ/kgK
18 sfg2=7.296;                           //in kJ/kgK
19
20 //as the steam expands isentropically , s1=s2
21 //sg1=sf2+x2*sfg2
22 x2=(s1-sf2)/sfg2;                     //dryness
        fraction
23 h2=hf2+x2*hfg2;
24
25 ETArankine=(h1-h2)/(h1-hf2);           //Rankine
        efficiency

```

```

26
27 ETAtthermal=IP/(m/3600*(h1-hf2));           //Thermal
    efficiency
28 ETAre1=ETAtthermal/ETArankine;               //Relative
    efficiency
29
30 printf(' (i) The Final condition of steam is: %1.2f.
    \n',x2);
31 printf(' (ii) The Rankine efficiency is: %1.4f or %2
    .2f percent. \n',ETArankine,(ETArankine*100));
32 printf('(iii) The Relative efficiency is: %1.3f or
    %2.1f percent. \n',ETAre1,(ETAre1*100));

```

---

#### Scilab code Exa 5.9 Example 9

```

1  clc
2  clear
3  //DATA GIVEN
4  T1=400+273;           //temp. in K
5  T2=T1;
6  T3=40+273;           //temp. in K
7  T4=T3;
8  W=130;               //work produced in kJ
9
10 ETAth=(T1-T3)/T1;     //Engine thermal
    efficiency
11
12 //ETAth=Work done/Heat added
13 Ha=W/ETAth;           //Heat added in kJ
14 Hr=Ha-W;              //Heat rejected in kJ
15 //Heat rejected=T3(S3-S4)
16 S34=Hr/T3;           //Entropy change during
    the heat rejection process
17
18 printf(' (i) The Engine thermal efficiency is: %1.3f

```

```

        or %2.1f percent. \n',ETAth,(ETAth*100));
19 printf(' (ii) The Heat added is: %3.0f kJ. \n',Ha);
20 printf('(iii) The Entropy change during the heat
    rejection process is: %1.3f kJ/K. \n',S34);

```

---

#### Scilab code Exa 5.10 Example 10

```

1  clc
2  clear
3  //DATA GIVEN
4  p1=18;                                //maximum
    pressure in bar
5  T1=410+273;                          //maximum
    temperature in K
6  T2=T1;
7  Rac=6;                               //ratio of
    isentropic or adiabatic compression, V4/V1=6
8  Rie=1.5;                             //ratio of
    isothermal expansion, V2/V1=1.5
9  V1=0.18;                             //volume of air
    at beginning of isothermal expansion in m^3
10 wc=210;                              //no. of cycles
    per s
11
12 //gamma for air=1.4
13 g=1.4;
14
15 //for isentropic process 4-1
16 //Also (T1/T4)=(V4/V1)^(g-1)
17 //(V4/V1)=Rac
18 T4=T1/Rac^(g-1);
19 T3=T4;
20 //p1(V1^gamma)=p4(V4^gamma)
21 //p4=p1*(V1/V4)^g
22 //where, (V4/V1)=Rac

```

```

23 p4=p1/(Rac^g);
24
25 //for isothermal process 1-2
26 //p1V1=p2V2
27 //V1/V2=1/Rie
28 p2=p1*(1/Rie);
29
30 //for isentropic process 2-3
31 //p2(V2^gamma)=p3(V3^gamma)
32 //V2/V3=V1/V4=1/Rac
33 p3=p2*(1/Rac)^g;
34
35 //change in entropy, DS=S2-S1=mRlog(V2/V1)=p1V1/T1*
    log(V2/V1)
36 DS=p1*10^5*V1/10^3/T1*log(Rie);
37
38 //Heat supplied, Qs=p1*V1*log(V2/V1)
39 //Qs=T1(S2-S1)
40 Qs=T1*DS;
41 //Qr=p4*V4*log(V3/V4) //heat
    rejected in kJ
42 //Qr=T4(S3-S4), bcs increase in entropy during heat
    addition is equal to decrease in entropy during
    heat rejection
43 Qr=T4*DS;
44
45 ETA=(Qs-Qr)/Qs; //mean
    thermal efficiency of the cycle
46
47 //mean effective pressure of the cycle, Pm = work
    done per cycle/stroke volume
48 Rv31=Rac*Rie; //ratio of
    volumes at 3 and 1, V3/V1=V3/V2*V2/V1
49 //stroke volume, Vs=V3-V1
50 Vs=V1*(Rv31-1);
51 J=1;
52 Pm=(Qs-Qr)*10^3/10^5*J/Vs;
53

```

```

54 P=(Qs-Qr)*wc/60;                                     //power of
    the engine in kW
55
56 printf(' (i) The Pressure and Temperature at point 1
    are:\n');
57 printf('                p1:%2.0f bar.\n',p1);
58 printf('                T1:%3.0f K.\n',T1);
59 printf('            The Pressure and Temperature at point
    2 are:\n');
60 printf('                p2:%2.0f bar.\n',p2);
61 printf('                T2:%3.0f K.\n',T2);
62 printf('            The Pressure and Temperature at point
    3 are:\n');
63 printf('                p3:%1.2f bar.\n',p3);
64 printf('                T3:%3.1f K.\n',T3);
65 printf('            The Pressure and Temperature at point
    4 are:\n');
66 printf('                p4:%1.2f bar.\n',p4);
67 printf('                T4:%3.1f K.\n',T4);
68 printf(' (ii) The Change in entropy during
    isothermal expansion is: %1.3f kJ/K. \n',DS);
69 printf('(iii) The Mean thermal efficiency of the
    cycle is: %1.3f or %2.1f percent. \n',ETA,(ETA
    *100));
70 printf(' (iv) The Mean effective pressure is: %1.3f
    bar. \n',Pm);
71 printf(' (v) The Power of the engine working on
    this cycle is given by: %3.1f kW. ',P);
72
73 //NOTE:
74 //there is slight variation in answers of book due
    to rounding off of the values

```

---

Scilab code Exa 5.11 Example 11

```

1  clc
2  clear
3  //DATA GIVEN
4  //CASE-1
5  //(T1-T2)/T1=1/6
6  //SO, T1=1.2(T2) ..... Eqn (1)
7
8  //CASE-2
9  //T2 REDUCED BY 70 DEG. CELSIUS
10 // {T1-[T2-(70+273)]}/T1 = 1 / 3 ..... Eqn (2)
11 // 2T1=3T2-1029
12
13 //By Eqn (1) and (2)
14 T2=(70+273)*3/(3-2*1.2);
15 T1=1.2*T2;
16
17 printf('(i) The Temperature of the Source, T1 is: %4
        .0f K or %4.0f deg. celsius. \n',T1,(T1-273));
18 printf('(ii) The Temperature of the Sink, T2 is: %4
        .0f K or %4.0f deg. celsius. \n',T2,(T2-273));

```

---

#### Scilab code Exa 5.12 Example 12

```

1  clc
2  clear
3  //DATA GIVEN
4  T1=1990; //Temperature of the
           heat Source in K
5  T2=850; //Temperature of the
           heat Sink in K
6  Qs=32.5; //heat supplied in kJ/
           min
7  P=0.4; //power developed by the
           engine in kW
8

```

```

9  ETAcarnot=(T1-T2)/T1;
10 //Also ETAth=work done/Heat supplied
11 ETAth=P/Qs;
12
13 printf('The Efficiency of carnot cycle is: %1.3f or
        %2.1f percent. \n',ETAcarnot,(ETAcarnot*100));
14 printf(' The Thermal efficiency of engine claimed by
        inventor is: %1.3f or %2.1f percent. \n\n',ETAth
        ,(ETAth*100));
15
16 if(ETAth>ETAcarnot)
17     printf(' Thus, The claim of the inventor is
        possible. ');
18 else
19     printf(' Thus, The claim of the inventor is NOT
        feasible, \n as no engine can be more
        efficient than that working on carnot cycle.'
        );

```

---

#### Scilab code Exa 5.13 Example 13

```

1  clc
2  clear
3  //DATA GIVEN
4  ETAotto=60; //Efficiency of otto
        cycle in %
5  shr=1.5; //ratio of specific
        heats
6
7  //ETAotto=1-1/(r)^(shr-1)
8  r=(1/(1-ETAotto/100))^(1/(shr-1)); //compression
        ratio
9
10 printf('The compression ratio is: %1.2f.',r);

```

---

### Scilab code Exa 5.14 Example 14

```

1  clc
2  clear
3  //DATA GIVEN
4  D=0.25;           //bore of the
    engine in m
5  L=0.375;          //stroke of the
    engine in m
6  Vc=0.00263;       //clearance
    volume in m^3
7  p1=1;             //initial
    pressure in bar
8  T1=50+273;        //initial
    temperature in K
9  p3=25;            //maximum
    pressure in bar
10
11 Vs=(%pi/4)*D^2*L; //swept volume
12 r=(Vs+Vc)/Vc;     //compression
    ratio
13
14 //for air , gamma=1.4
15 g=1.4;
16 //Air standard efficiency of otto cycle ETAotto
    =1-1/(r)^(g-1)
17 ETAotto=1-1/(r)^(g-1);
18
19 //for adiabatic process 1-2
20 //p1(V1^gamma)=p2(V2^gamma)
21 //p2=p1*(V1/V2)^g
22 //where , (V1/V2)=r
23 p2=p1*(r^g);      //
    pressure at 2 in bar

```

```

24 rp=p3/p2;                                     //
    pressure ratio
25 Pm=p1*r*[(r^(g-1)-1)*(rp-1)]/[(g-1)*(r-1)]; //mean
    effective pressure in bar
26
27 printf(' (i) The Air standard efficiency of otto
    cycle is: %1.3f or %2.1f percent. \n',ETAotto,(
    ETAotto*100));
28 printf(' (ii) The Mean effective pressure is: %1.3f
    bar. \n',Pm);

```

---

#### Scilab code Exa 5.15 Example 15

```

1  clc
2  clear
3  //DATA GIVEN
4  T1=38+273;                                     //initial
    temperature in K
5  T3=1950+273;                                     //maximum
    temperature K
6  rp=15;                                           //pressure ratio
7  //for air , gamma=1.4
8  g=1.4;
9
10 //for adiabatic compression 1-2
11 //p1(V1^gamma)=p2(V2^gamma)
12 //(V1/V2)=r
13 r=(rp)^(1/g);
14
15 //Thermal efficiency ETAth=1-1/(r)^(g-1)
16 ETAth=1-1/(r)^(g-1);
17
18 //for adiabatic compression 1-2
19 //(T2/T1)=(V1/V2)^(g-1)
20 //(V1/V2)=r

```

```

21 T2=T1*r^(g-1);
22
23 //for adiabatic expansion 3-4
24 //(T3/T4)=(V4/V3)^(g-1)
25 //(V4/V3)=r
26 T4=T3/r^(g-1);
27
28 //heat supplied per kg of air , Qs=m*Cv*(T3-T2)
29 R=0.287;
30 Cv=R/(g-1);
31 Qs=Cv*(T3-T2);
32
33 //heat rejected per kg of air , Qr=m*Cv*(T4-T1)
34 Qr=Cv*(T4-T1);
35
36 W=Qs-Qr; //work done per kg
    of air
37
38 printf(' (i) The compression ratio is: %1.1f.\n',r);
39 printf(' (ii) The Thermal efficiency is: %1.3f or %2
    .1f percent. \n',ETAth,(ETAth*100));
40 printf(' (iii) The Work done is: %3.1f kJ or %6.0f Nm
    . ',W,(W*1000));
41
42 //NOTE:
43 //there is slight variation in answers in the book
    because of rounding off of the values

```

---

#### Scilab code Exa 5.16 Example 16

```

1  clc
2  clear
3  //DATA GIVEN
4  V1=0.45; //volume in m^3
5  p1=1; //initial pressure

```

```

        in bar
6  T1=30+273;                                //initial
        temperature in K
7  p2=11;                                    //pressure at the
        end of compression stroke in bar
8  Qs=210;                                    //heat addaed at
        constant volume in kJ
9  wc=210;                                    //no. of working
        cycles/min
10
11 //for air , gamma=1.4
12 g=1.4;
13
14 //for adiabatic compression 1-2
15 //p1(V1^gamma)=p2(V2^gamma)
16 //(V1/V2)=r
17 r=(p2/p1)^(1/g);
18 //Also (T2/T1)=(V1/V2)^(g-1)
19 //(V1/V2)=r
20 T2=T1*r^(g-1);
21
22 //Applying gas laws to points 1 and 2
23 //p1V1/T1=p2V2/T2
24 V2=T2/T1*p1/p2*V1;
25
26 //heat supplied during process 2-3, Qs=mCv(T3-T2)
27 R=287;
28 m=p1*10^5*V1/R/T1;
29 Cv=R/1000/(g-1);
30 T3=Qs/m/Cv+T2;
31
32 //for constant volume process 2-3
33 //p3/T3=p2/T2
34 p3=p2/T2*T3;
35 V3=V2;
36
37 //for adiabatic expansion 3-4
38 //p3(V3^gamma)=p4(V4^gamma)

```

```

39 // (V4/V3)=r
40 p4=p3*(1/r)^(g);
41 // Also T3/T4)=(V4/V3)^(g-1)
42 // (V4/V3)=r
43 T4=T3/r^(g-1);
44 V4=V1;
45
46 //percentage clearance , pc=Vc/Vs=V2/(V1-V2)
47 pc=V2/(V1-V2)*100;
48
49 //heat rejected per cycle , Qr=Cv*(T4-T1)
50 Qr=m*Cv*(T4-T1);
51
52 //Air standard efficiency of otto cycle ETAotto=(Qs-
    Qr)/Qs
53 ETAotto=(Qs-Qr)/Qs;
54 // Alternatively
55 //ETAotto=1-1/(r)^(g-1)
56 ETAotto=1-1/(r)^(g-1);
57
58 //mean effective pressure , Pm=W/Vs
59 W=Qs-Qr; //work done per kg
    of air
60 Vs=V1-V2;
61 Pm=W*10^3/10^5/Vs;
62
63 //power developed , P=work done per cycle*no. of
    cycles per s
64 P=W*(wc/60);
65
66 printf(' (i) The Pressure , Temperature and Volumes
    at salient points in the cycle are:\n');
67 printf(' At point 1 are:\n');
68 printf(' p1:%1.1f bar.\n',p1);
69 printf(' V1:%1.2f m^3.\n',V1);
70 printf(' T1:%3.0f K.\n',T1);
71 printf(' At point 2 are:\n');
72 printf(' p2:%2.2f bar.\n',p2);

```

```

73 printf('                V2:%1.3 f m^3.\n',V2);
74 printf('                T2:%3.0 f K.\n',T2);
75 printf('            At point 3 are:\n');
76 printf('                p3:%2.2 f bar.\n',p3);
77 printf('                V3:%1.3 f m^3.\n',V3);
78 printf('                T3:%4.0 f K.\n',T3);
79 printf('            At point 4 are:\n');
80 printf('                p4:%1.2 f bar.\n',p4);
81 printf('                V4:%1.2 f m^3.\n',V4);
82 printf('                T4:%3.1 f K.\n',T4);
83 printf(' (ii) The Percentage clearance is: %2.2 f
    percent. \n',pc);
84 printf('(iii) The Air standard efficiency of the
    cycle is: %1.3 f or %2.1 f percent. \n',ETAotto,(
    ETAotto*100));
85 printf(' (iv) The Mean effective pressure is: %1.3 f
    bar. \n',Pm);
86 printf(' (v) The Power developed is: %3.1 f kW. ',P);
87
88 //NOTE:
89 //there is slight variation in answers in the book
    because of rounding off of the values

```

---

#### Scilab code Exa 5.17 Example 17

```

1  clc
2  clear
3  //DATA GIVEN
4  r=15;                                //compression ratio
5  //V3-V2=a/100*Vs..... Vs=stroke volume=V1-V2
6  //V3=1.84V2
7  c=6;                                //heat addition takes
    place at 'a' percent of stroke
8  //for air, gamma=1.4
9  g=1.4;

```

```

10
11 //Air standard efficiency of diesel cycle ETAdiesel
    =1-[1/(r)^(g-1)][(rho^g-1)/(rho-1)]
12 //rho=cut off ratio=V3/V2
13 rho=c/100*(r-1)+1;
14 ETAdiesel=1-[1/g/(r)^(g-1)]*[(rho^g-1)/(rho-1)];
15
16 printf(' The Air standard efficiency of diesel cycle
    is: %1.3f or %2.1f percent. \n',ETAdiesel,(
    ETAdiesel*100));

```

---

#### Scilab code Exa 5.18 Example 18

```

1  clc
2  clear
3  //DATA GIVEN
4  L=0.25;                                //stroke of the
    engine in m
5  D=0.15;                                //diameter of
    cylinder in m
6  V2=0.0004;                             //clearance
    volume in m^3
7  Vs=(%pi/4)*D^2*L;                      //swept volume in
    m^3
8  Vt=Vs+V2;                              //total cylinder
    volume in m^3
9  c=5;                                    //fuel injection
    takes place at 'c' percent of stroke
10 V3=V2+c/100*Vs;                         //volume at point
    of cut-off in m^3
11 rho=V3/V2;                             //cut-off ratio
12 r=(Vs+V2)/V2;                          //compression
    ratio
13
14 //for air , gamma=1.4

```

```

15 g=1.4;
16
17 //Air standard efficiency of diesel cycle ETAdiesel
    =1-[1/(r)^(g-1)]*[(rho^g-1)/(rho-1)]
18 ETAdiesel=1-[1/g/(r)^(g-1)]*[(rho^g-1)/(rho-1)];
19
20 printf(' The Efficiency of diesel engine is: %1.3f
    or %2.1f percent. \n',ETAdiesel,(ETAdiesel*100));

```

---

#### Scilab code Exa 5.19 Example 19

```

1  clc
2  clear
3  //DATA GIVEN
4  r=14; //compression ratio
5  //fuel cut-off is delayed from 5-8%
6  //for air, gamma=1.4
7  g=1.4;
8
9  //when fuel is cut-off at 5%
10 c1=5;
11 rho1=c1/100*(r-1)+1;
12 //Efficiency of diesel engine ETAdiesel=1-[1/(r)^(g
    -1)]*[(rho^g-1)/(rho-1)]
13 ETAdiesel1=1-[1/g/(r)^(g-1)]*[(rho1^g-1)/(rho1-1)];
14
15 //when fuel is cut-off at 8%
16 c2=8;
17 rho2=c2/100*(r-1)+1;
18 //Efficiency of diesel engine ETAdiesel=1-[1/(r)^(g
    -1)]*[(rho^g-1)/(rho-1)]
19 ETAdiesel2=1-[1/g/(r)^(g-1)]*[(rho2^g-1)/(rho2-1)];
20
21 ETAlloss=(ETAdiesel1-ETAdiesel2)*100;
22

```

```

23 printf(' The Percentage loss in efficiency due to
    delay in fuel cut-off is: %1.1f percent. \n',
    ETAlloss);

```

---

#### Scilab code Exa 5.20 Example 20

```

1 clc
2 clear
3 //DATA GIVEN
4 Pm=7.5;                                //mean effective
    pressure in bar
5 r=12.5;                                //compression ratio
6 p1=1;                                  //initial pressure in
    bar
7
8 //for air , gamma=1.4
9 g=1.4;
10
11 //mean effective pressure ,  $P_m = p_1 * r^g * [g * (\rho - 1) - r$ 
     $^{(1-g)} * (\rho^g - 1)] / [(g-1) * (r-1)]$ 
12 //we get ,  $0.346(\rho)^{1.4} - 1.4(\rho) + 2.04$ 
13 //By trial and error method, we get
14 rho=2.24;
15
16 co=(rho-1)/(r-1)*100;                  //% cut-off
17
18 printf(' The Percentage cut-off of the cycle is: %2
    .2f percent. \n',co);

```

---

#### Scilab code Exa 5.21 Example 21

```

1 clc
2 clear

```

```

3 //DATA GIVEN
4 D=0.2; //bore of the
    engine in m
5 L=0.3; //stroke of the
    engine in m
6 p1=1; //initial
    pressure in bar
7 T1=27+273; //initial
    temperature in K
8 c=8; //cut-off % of
    stroke volume
9 r=15; //compression
    ratio
10 wc=380; //no. of cycles
    per s
11
12 Vs=(%pi/4)*D^2*L; //swept volume in
    m^3
13 V1=Vs*(1+1/(r-1)); //in m^3
14 //for air, gamma=1.4
15 g=1.4;
16
17 R=287;
18 m=p1*10^5*V1/R/T1; //mass of air in
    the cylinder in kg/cycle
19
20 //for adiabatic process 1-2
21 //p1(V1^gamma)=p2(V2^gamma)
22 //p2=p1*(V1/V2)^g
23 //where, (V1/V2)=r
24 p2=p1*(r^g); //
    pressure at 2 in bar
25 //Also (T2/T1)=(V1/V2)^(g-1)
26 //(V1/V2)=r
27 T2=T1*r^(g-1);
28 V2=Vs/(r-1);
29 Vc=V2;
30 p3=p2;

```

```

31
32 //cut-off ratio ,  $c=(\rho-1)/(r-1)$ 
33  $\rho=c/100*(r-1)+1$ ;
34  $V3=\rho*V2$ ;
35 //alternatively
36  $V3=c/100*Vs+Vc$ ;
37
38 //for constant pressure process 2-3
39  $V3/T3=V2/T2$ 
40  $T3=T2/V2*V3$ ;
41
42 //for isentropic process 3-4
43  $p3(V3^\gamma)=p4(V4^\gamma)$ 
44  $((V4/V)=V4/V2*V2/V3=V1/V2*V2/V3=r/\rho)$ 
45  $p4=p3*((\rho/r)^\gamma)$ ;
46 //Also  $(T4/T3)=(V3/V4)^{(g-1)}$ 
47  $((V4/V)=V4/V2*V2/V3=V1/V2*V2/V3=r/\rho)$ 
48  $T4=T3*((\rho/r)^{(g-1)})$ ;
49  $V4=V1$ ;
50
51 //Air standard efficiency of diesel cycle  $ET_{Adiesel}$ 
52  $=1-[1/(r)^{(g-1)}][(\rho^{g-1})/(\rho-1)]$ 
53  $ET_{Adiesel}=1-[1/g/(r)^{(g-1)}]*[(\rho^{g-1})/(\rho-1)]$ ;
54 //mean effective pressure ,  $P_m=p1*r^\gamma*[g*(\rho-1)-r^{(1-g)}*(\rho^{g-1})]/[(g-1)*(r-1)]$ ;
55  $P_m=p1*r^\gamma*[g*(\rho-1)-r^{(1-g)}*(\rho^{g-1})]/[(g-1)*(r-1)]$ ;
56
57  $P=P_m*10^5*Vs/10^3*(wc/60)$ ; //Power of
    the engine in kW
58
59 printf(' (i) The Pressure , Temperature and Volumes
    at salient points in the cycle are:\n');
60 printf('          At point 1 are:\n');
61 printf('          p1:%1.1f bar.\n',p1);
62 printf('          V1:%1.4f m^3.\n',V1);
63 printf('          T1:%3.0f K.\n',T1);

```

```

64 printf('          At point 2 are:\n');
65 printf('                p2:%2.2f bar.\n',p2);
66 printf('                V2:%1.7f m^3.\n',V2);
67 printf('                T2:%3.1f K.\n',T2);
68 printf('          At point 3 are:\n');
69 printf('                p3:%2.2f bar.\n',p3);
70 printf('                V3:%1.6f m^3.\n',V3);
71 printf('                T3:%4.1f K.\n',T3);
72 printf('          At point 4 are:\n');
73 printf('                p4:%1.3f bar.\n',p4);
74 printf('                V4:%1.4f m^3.\n',V4);
75 printf('                T4:%3.2f K.\n',T4);
76 printf(' (ii) The Theoretical air standard
        efficiency of diesel cycle is: %1.3f or %2.1f
        percent. \n',ETAdiesel,(ETAdiesel*100));
77 printf('(iii) The Mean effective pressure is: %1.3f
        bar. \n',Pm);
78 printf(' (iv) The Power developed is: %2.2f kW. ',P);

```

---

# Chapter 6

## Steam Boilers

Scilab code Exa 6.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  LCV=44700;           //LCV of fuel in kJ
5  afrn=20;            //air parts=20 in air fuel
   mixture
6  afrd=1;             //fuel parts=1 in air fuel
   mixture
7  Cpg=1.08;           //avg specific heat in kJ/
   kgK
8  T1=38+273;          //boiler room temp. in K
9
10 //heat of combustion=heat of gases
11 //1*44700=Mg*Cpg*(T2-T1)
12 T2=afrd*LCV/(afrn+afrd)/Cpg+T1;
13
14 printf(' The Maximum temp. T2 attained in the
   furnace of the boiler is:\n %5.0f Kelvin ',T2);
15 printf('or %5.0f degree celsius.\n',(T2-273));
```

---

### Scilab code Exa 6.2 Example 2

```
1  clc
2  clear
3  //DATA GIVEN
4  Ms=5.4;                      //mass of steam used in kg/
    kWh
5  p=50;                        //pressure of steam in bar
6  Tsup=350;                    //temp. of steam in deg
    celsius
7  eta=82;                      //boiler efficiency in %
8  Tfw=150;                     //feed water temp. in deg cel
    ;sius
9  C=28100;                     //calorific value of coal in
    kJ
10 rate=500;                    //cost of coal/tonne in Rs
11
12 //boiler efficiency is given by,  $\eta = \frac{M_s(h_{sup} - h_{f1})}{M_f C}$ 
13 //from steam table, at 45 bar and 350deg celsius,
    hsup=3068.4 kJ/kg
14 h=3068.4;                    //enthalpy at
    45 bar and 350 deg celsius
15 hf1=4.18*(Tfw-0);            //hf1 at 150
    deg celsius in kJ/kg
16
17 //subs. these in eq. of boiler efficiency
18 Mf=Ms*(h-hf1)/((eta/100)*C); //mass of coal
    required in kg/kWh
19 cost=(Mf/1000)*rate*100;     //cost of coal
    in paisa/kWh
20
21 printf(' (i) The mass of coal required is: %5.3f kg
    /kWh. \n',Mf);
```

```

22 printf(' (ii) The Total cost of fuel(coal) is: %2.1
    f paisa/kWh. \n',cost);
23
24 //NOTE:in text book
25 //in question pressure is given as =50 bar
26 //but from steam table enthalpy is found at 45 bar

```

---

### Scilab code Exa 6.3 Example 3

```

1  clc
2  clear
3  //DATA GIVEN
4  Mc=1250; //quantity of coal in kg
    consumed in 24 hours
5  Mw=13000; //mass of water
    evaporated in kg
6  MEPs=7; //mean effective pressure
    of steam in bar
7  Tfw=40; //feed water temp. in deg
    celsius
8  h=2570.7; //enthalpy of steam at 7
    bar in kJ/kg
9  C=30000; //calorific value of coal
    in kJ/kg
10
11 Ma=Mw/Mc; //mass of water actually
    evaporated per kg of fuel
12 hf1=4.18*(Tfw-0);
13 hfg=2257; //in kJ/kg
14 Me=Ma*(h-hf1)/hfg; //in kg
15 eta=Ma*(h-hf1)/C; //boiler efficiency
16
17 printf(' (i) The equivalent evaporation per kg of
    coal, Me is: %5.3f kg. \n',Me);
18 printf(' (ii) The efficiency of boiler, eta is: %1

```

```
.3 f or %2.1 f percent. ',eta,eta*100);
```

---

#### Scilab code Exa 6.4 Example 4

```
1  clc
2  clear
3  //DATA GIVEN
4  p=12;                      //mean steam pressure in
    bar
5  Ms=40000;                  //mass of steam generated
    in kg
6  x=0.85;                   //mean dryness fraction
7  Tfw=30;                   //mean feed water temp. in
    deg celsius
8  Mc=4000;                  //mass of coal used in kg
9  C=33400;                  //calorific value of coal
    in kJ/kg
10
11 //from steam table , corresponding to 12 bar ,
12 hf=798.4;                  //in kJ/kg
13 hfg=1984.3;               //in kJ/kg
14 h=hf+x*hfg;               //in kJ/kg
15 hf1=4.18*(Tfw-0);         //heat of feed water in kJ/
    kg
16
17 Fe=(h-hf1)/2257;           //factor of equivalent
    evaporation ,Fe
18 Ma=Ms/Mc;                 //per kg of fuel
19 Me=Ma*(h-hf1)/2257;       /(kg of steam)/(kg of fuel
    )
20 eta=Ma*(h-hf1)/C;         //efficiency of boiler
21
22 printf(' (i) The Factor of equivalent temerature ,Fe
    is: %5.3 f\n',Fe);
23 printf(' (ii) The Equivalent evaporation from and
```

```

        at 100 deg celsius , Me is: %5.2f (kg of steam)/(
        kg of coal).\n',Me);
24 printf(' (iii) The Efficiency of boiler is: %5.4f ',
        eta);
25 printf('or %5.2f percent. \n',eta*100);

```

---

#### Scilab code Exa 6.5 Example 5

```

1  clc
2  clear
3  //DATA GIVEN
4  M=18000;           //mass of steam generated in
        kg/hr
5  p=12.5;           //steam pressure in bar
6  x=0.97;           //quality of steam
7  Tfw=105;          //feed water temp. in deg
        celsius
8  Mf=2040;          //rate of coal firing in kg/
        hr
9  C=27400;           //highrer calorific value (
        HCV) of coal in kJ/kg
10
11 //from steam table , corresponding to 12.5 bar ,
12 hf=806.7;          //in kJ/kg
13 hfg=1977.4;        //in kJ/kg
14 h=hf+x*hfg;        //in kJ/kg
15 hf1=4.18*(Tfw-0);  //heat of feed water in kJ/
        kg
16
17 //heat rate of the boiler = heat supplied per hour
18 heatrate=M*(h-hf1) //heat rate of boiler
19 Ma=M/Mf;           //in kg per kg of fuel
20 Me=Ma*(h-hf1)/2257; // (kg of steam)/(kg of fuel)
21 eta=Ma*(h-hf1)/C;  //thermal efficiency
22

```

```

23 printf(' (i) The Heat rate of boiler is: %1.4e kJ/h.
    \n',heatrate);
24 printf(' (ii) The Equivalent evaporation, Me is: %5
    .3f (kg of steam)/(kg of fuel). \n',Me);
25 printf('(iii) The Thermal efficiency is: %5.4f ',eta
    );
26 printf('or %5.2f percent. \n',eta*100);

```

---

### Scilab code Exa 6.6 Example 6

```

1  clc
2  clear
3  //DATA GIVEN
4  Mw=5940;           //mass of water evaporated kg/hr
5  Mc=675;            //mass of coal burnt in kg/hr
6  C=31600;           //lower calorific value(LCV) of
    coal in kJ/kg
7  p1=14;             //pressure of steam at boiler
    stop valve in bar
8  Te1=32;            //temp. of feed water entering
    economiser in deg celsius
9  Te2=115;           //temp. of feed water leaving
    economiser in deg celsius
10 x=0.96;            //dryness fraction of steam
    entering superheater
11 Tsup=260;          //temp. of steam leaving
    superheater in deg celsius
12 Cp=2.3             //specific heat of superheated
    steam
13
14 hf1=4.18*(Te2-Te1); //heat
    utilised by 1 kg of feed water in economiser
15 //from steam table, corresponding to 14 bar,
16 Ts=195;
17 hf=830.1;

```

```

18 hfg=1957.7;
19 hboiler=(hf+x*hfg)-hf1;           //heat
    utilised by 1 kg of feed water in boiler
20 hsuperheater=(1-x)*hfg+Cp*(Tsup-Ts); //heat
    utilised by 1 kg of feed water in superheater
21 Ma=Mw/Mc;                       //in kg per
    kg of fuel
22 Pe=hf1/C*Ma*100;                 //% of heat
    utilised in economiser
23 Pb=hboiler/C*Ma*100;             //% of heat
    utilised in boiler
24 Ps=hsuperheater/C*Ma*100;        //% of heat
    utilised in superheater
25 httotal=hf1+hboiler+hsuperheater; //total heat
    absorbed in kg of water
26 eta=Ma*httotal/C;                //overall
    efficiency of boiler plant
27
28 printf(' (i) The Percentage of heat utilised in
    Economiser is: %5.2f percent.\n',Pe);
29 printf('      The Percentage of heat utilised in
    Boiler is: %5.2f percent.\n',Pb);
30 printf('      The Percentage of heat utilised in
    Superheater is: %5.2f percent.\n',Ps);
31 printf(' (ii) The Overall Efficiency of boiler plant
    is: %5.4f ',eta);
32 printf('or %5.2f percent. \n',eta*100);

```

---

#### Scilab code Exa 6.7 Example 7

```

1  clc
2  clear
3  //DATA GIVEN
4  C=29915;           //calorific value of coal in kJ/
    kg

```

```

5 Mw=9.1;           //mass of feed water per kg of
   dry coal in kg
6 Me=9.6;           //equivalent evaporation from
   and at 100 deg celsius per kg of dry coal in kg
7 Te=12;           //temp. of feed water to
   economiser in deg celsius
8 Tb=105;          //temp. of feed water to boiler
   in deg celsius
9 Ta=13;           //temp. of air
10 Tfg=370;        //temp. of flue gases entering
   economiser
11 Mfg=18.2;       //mass of flue gases entering
   economiser per kg of coal
12 Cp=1.046;       //mean specific heat of flue
   gases
13
14 hb=Me*2257;      //heat supplied for steam
   generation in kJ
15 ETAb=hb/C;       //boiler efficiency
16 hflue=Mfg*Cp*(Tfg-Ta); //heat in the flue gas
   per kg of dry coal entering economiser
17 he=Mw*4.184*(Tb-Te); //heat utilised in
   economiser
18 ETAe=he/hflue;   //economiser efficiency
19 httotal=hb+he;   //total heat absorbed in
   kg of water
20 ETA=httotal/C;   //boiler plant efficiency
21
22 printf(' (i) The Boiler efficiency is: %5.3f ',ETAb)
   ;
23 printf('or %2.1f percent. \n',ETAb*100);
24 printf(' (ii) The Economiser efficiency is: %5.3f ',
   ETAe);
25 printf('or %2.2f percent. \n',ETAe*100);
26 printf('(iii) The Overall Efficiency of boiler plant
   is: %5.3f ',ETA);
27 printf('or %2.1f percent. \n',ETA*100);

```

---

### Scilab code Exa 6.8 Example 8

```
1  clc
2  clear
3  //DATA GIVEN
4  Ms=2000;           //rate of steam production in kg
   /hr
5  x=1;              //quality of steam
6  p=10;             //steam pressure in bar
7  Tfw=110;          //feed water temp. in deg
   celsius
8  Mf=225;           //rate of coal firing in kg/hr
9  C=30100;          //calorific value of coal in kJ/
   kg
10 Puc=10;           //% of unburnt coal
11
12 //from steam table, corresponding to 10 bar,
13 h=2776.2;          //in kJ/kg
14 hf1=4.18*(Tfw-0); //heat contained in 1kg
   of feed water before entering boiler in kJ/kg
15 httotal=h-hf1     //total heat given to
   produce 1 kg of steam in boiler in kJ/kg
16 Mc=Mf*(100-Puc)/100; //mass of coal actually
   burnt in kg
17 Ma=Ms/Mc;           //(kg of steam)/(kg of
   fuel)
18 ETAb=Ma*(h-hf1)/C; //thermal efficiency of
   boiler
19 ETAc=(Ms/Mf)*(h-hf1)/C; //thermal efficiency of
   boiler and grate combined
20
21 printf(' (i) The Thermal efficiency of the boiler is
   : %5.3f ',ETAb);
22 printf('or %5.2f percent. \n',ETAb*100);
```

```

23 printf(' (ii) The Thermal efficiency of the boiler
    and grate combined is: %5.3f ',ETAc);
24 printf('or %5.2f percent. \n',ETAc*100);

```

---

#### Scilab code Exa 6.9 Example 9

```

1  clc
2  clear
3  //DATA GIVEN
4  Ma=7.5;           //mass of steam generated per kg
    of coal
5  p=11;             //steam pressure in bar
6  Tfw=70;           //temp. of feed water temp. in
    deg celsius
7  eta=75;           //efficiency of boiler in %
8  Fe=1.15;          //factor of evaporation
9  Cps=2.3;          //specific heat of steam in kJ/
    kgK
10
11 //from steam table, corresponding to 11 bar,
12 hf=781.4;          //in kJ/kg
13 hfg=1998.5;        //in kJ/kg
14 Ts=184.1+273;     //in K
15 hf1=4.18*(Tfw-0);
16
17 //Factor of evaporation, Fe=[{hf+hfg+Cps*(Tsup-Ts)}-
    hf1]/2257
18 Tsup=[Fe*2257+hf1-hf-hfg]/Cps+Ts;           //Tsup in K
19 x=(Tsup-Ts);                                     //degree of
    superheat in deg. celsius
20
21 //Boiler efficiency eta=Ma*(h-hf1)/C;
22 h=[hf+hfg+Cps*(Tsup-Ts)];
23 C=Ma*(h-hf1)/(eta/100);                         //calorific
    value of coal in kJ/kg

```

```

24 Me=Ma*(h-hf1)/2257;                                     //
    Equivalent evaporation in kg
25
26 printf(' (i) The Temperature of steam generation ,
    Tsup is: %5.1f K\n',Tsup);
27 printf('          The Degree of superheat is: %5.1f deg
    celsius.\n',x);
28 printf(' (ii) The calorific value of coal, C is: %5
    .0f kJ/kg. \n',C);
29 printf('(iii) The Equivalent evaporation, Me is: %5
    .3f kg. \n',Me);

```

---

#### Scilab code Exa 6.10 Example 10

```

1  clc
2  clear
3  //DATA GIVEN
4  p=13;                                     //steam pressure in bar
5  ds=77;                                     //degree of superheat in
    deg. celsius
6  Tfw=85;                                     //temp. of feed water in
    deg. celsius
7  Mw=3000;                                     //mass of water
    evaporated in kg/hr
8  Mc=410;                                     //coal fired
9  Mash=40;                                     //mass of ash in kg/hr
10 Pca=9.6;                                     //% of combustible in
    ash
11 Pm=4.5;                                     //% of moisture in coal
12 C=30500;                                     //calorific vaalue of
    dry coal per kg
13 Cps=2.1;                                     //specific heat of
    superheated steam in kJ/kgK
14
15

```

```

16 //from steam table , corresponding to 13 bar ,
17 hf=814.7; //in kJ/kg
18 hfg=1970.7; //in kJ/kg
19 Ts=191.6; //in deg. selsius
20 h=hf+hfg+Cps*(ds);
21 hf1=4.18*(Tfw-0);
22 httotal=h-hf1; //total heat supplied to
    produce 1 kg of steam
23
24 Mc1=Mc*(1-Pm/100); //mass of dry coal in kg
25 Ma=Mw/Mc1;
26 ETAb=Ma*(h-hf1)/C; //efficiency of boiler
    plant including superheater
27
28 Mcom=Mash*Pca/100; //Mass of combustible in
    ash per hr
29 //the combustible present in ash is practically
    carbon and its value may be taken as 338/60 kJ/kg
30 //heat actually supplied pr hr=heat of dry coal-heat
    of combustible in ash
31 Hsupp=Mc1*C-Mcom*33860; //heat actually supplied
    pr hr
32 Huse=Mw*(h-hf1); //heat usefully utilised
    in boiler pr hr
33
34 ETAc=Huse/Hsupp; //efficiency of boiler
    and furnace combined
35
36 printf(' (i) The Efficiency of boiler plant
    including superheater is: %5.3f or %2.1f percent.
    \n',ETAb,(ETAb*100));
37 printf(' (ii) The Efficiency of the boiler and
    furnace combined is: %5.3f or %2.1f percent. \n',
    ETAc,(ETAc*100));

```

---

### Scilab code Exa 6.11 Example 11

```
1  clc
2  clear
3  //DATA GIVEN
4  Ms=5000;           //mass of steam generated in
    kg/hr
5  Mf=700;           //rate of coal firing in kg/
    hr
6  C=31402;          //higher calorific value(HCV
    ) of coal in kJ/kg
7  x=0.92;           //quality of steam
8  p=12;             //steam pressure in bar
9  Tfw=45;           //feed water temp. in deg
    celsius
10
11 //from steam table, corresponding to 12 bar,
12 hf=798.4;          //in kJ/kg
13 hfg=1984.3;        //in kJ/kg
14 h=hf+x*hfg;        //in kJ/kg
15 hf1=4.18*(Tfw-0);  //heat of feed water in kJ/
    kg
16 Ma=Ms/Mf;          //in kg per kg of fuel
17 Me=Ma*(h-hf1)/2257; //((kg of steam)/(kg of fuel)
18 eta=Ma*(h-hf1)/C;   //thermal efficiency
19
20 printf(' (i) The Equivalent evaporation, Me is: %5.3
    f (kg of steam)/(kg of coal). \n',Me);
21 printf(' (ii) The Boiler efficiency is: %5.3f or %2
    .1f percent. \n',eta,eta*100);
```

---

### Scilab code Exa 6.12 Example 12

```
1  clc
2  clear
```

```

3 //DATA GIVEN
4 hsup=3373.7; //enthalpy of steam (at
    100 bar,500 deg. celsius) in kJ/kg
5 hf1=677; //enthalpy of feed water
    (at inlet temp. 160 deg. celsius) in kJ/kg
6 hf=1407.65; //ennthalpy of saturated
    liquid at 100 bar in kJ/kg
7 hg=2724.7; //ennthalpy of saturated
    vapout at 100 bar in kJ/kg
8 Ms=100000; //rate of steam
    generation in kg/hr
9 eta=88; //efficiency of steam
    generation
10 C=21000; //calorific value of fuel
    in kJ/kg
11
12 //eta=(heat absorbed by steam per hr)/(heat added by
    fuel per hour)
13 m=Ms*(hsup-hf1)/(C*(eta/100)); //fuel burning
    rate in kg/hr
14 httotal=hsup-hf1; //total heat
    supplied to steam formation
15 Pec=(hf-hf1)/httotal; //% of heat
    absorbed in economiser
16 Pev=(hg-hf)/httotal; //% of heat
    absorbed in evaporator
17 Ps=(hsup-hg)/httotal; //% of heat
    absorbed in superheater
18
19 printf(' (i) The Fuel burning rate , m is: %5.1f kJ/h
    . \n',m);
20 printf(' (ii) The Percentage of heat absorbed in
    economiser is: %5.4f or %5.2f percent.\n',Pec,(
    Pec*100));
21 printf(' The Percentage of heat absorbed in
    evaporator is: %5.4f or %5.2f percent.\n',Pev,(
    Pev*100));
22 printf(' The Percentage of heat absorbed in

```

```
superheater is: %5.4f or %5.2f percent.\n',Ps,(Ps
*100));
```

---

### Scilab code Exa 6.13 Example 13

```
1  clc
2  clear
3  //DATA GIVEN
4  //BOILER
5  Mw=2060;           //mass of feed water
6  Mc=227;           //mass of coal supplied in kg/hr
7  C=30000;          //calorific value of coal in kJ/
    kg
8  hs=2750;           //enthalpy of steam produced in
    kJ/kg
9  hfw=398;           //enthalpy of feed water
10 //ECONOMISER
11 Twin=15;           //temp. of feed water entering
    economiser in deg celsius
12 Twout=95;          //temp. of feed water leaving
    economiser in deg celsius
13 Tgout=18;           //atmospheric temp.
14 Tgin=370;           //temp. of entering flue gases
15 Mfg=4075;          //mass of flue gases
16 //assuming Cpw and Cpg,
17 Cpw=4.187;
18 Cpg=1.01;
19
20 ETAb=Mw*(hs-hfw)/(Mc*C);           //efficiency of
    boiler
21 ETAe=Mw*Cpw*(Twout-Twin)/(Mfg*Cpg*(Tgin-Tgout));
    //efficiency of economiser
22
23 printf(' (i) The Boiler efficiency is: %5.4f or %2.2
```

```

        f percent. \n',ETAb,(ETAb*100));
24 printf(' (ii) The Economiser efficiency is: %5.3f or
        %2.1f percent. \n',ETAe,(ETAe*100));

```

---

#### Scilab code Exa 6.14 Example 14

```

1  clc
2  clear
3  //DATA GIVEN
4  Tfw=50;           //mean feed  water temp. in deg
                    celsius
5  p=5;             //mean steam pressure in bar
6  x=0.95;          //dryness fraction of steam
7  Mc=600;          //coal consumption kg/hr
8  C=30400;         //calorific value of coal in kJ/
                    kg
9  Ms=4800;         //feed water supplied to boiler
                    in kg/hr
10
11 //from steam table, corresponding to 12 bar,
12 hf=640.1;        //in kJ/kg
13 hfg=2107.4;      //in kJ/kg
14 h=hf+x*hfg;      //in kJ/kg
15 hf1=4.18*(Tfw-0);
16
17 Ma=Ms/Mc;        //in kg per kg of fuel
18 Me=Ma*(h-hf1)/2257; //(kg of steam)/(kg of fuel)
19
20 printf(' The Equivalent evaporation from and at 100
        deg celsius, Me is: %5.3f (kg of steam)/(kg of
        coal).\n',Me);

```

---

# Chapter 7

## Internal Combustion Engines

Scilab code Exa 7.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  Pmi=6;                                //mean effective
    pressure in bar
5  N=1000;                               //engine speed in R.P.
    M.
6  D=0.11;                               //diameter of piston
    in m
7  L=0.14;                               //stroke length in m
8  n=1;                                  //no. of cylinders
9  k=1;                                  //for 2-stroke
    cylinder
10
11 //INDICTED POWER , I.P.=(n*PMI*l*A*N*k*10)/6 kW
12 A=(%pi/4)*(D^2);
13 IP=(n*Pmi*L*A*N*k*10)/6;
14
15 printf('The Indicted Power developed is: %2.1f kW.',
    IP);
```

---

### Scilab code Exa 7.2 Example 2

```
1  clc
2  clear
3  //DATA GIVEN
4  //L=1.5D
5  n=4;                                //no. of cylinders
6  P=14.7;                             //power developed in
    kW
7  N=1000;                             //engine speed in R.P.
    M.
8  Pmi=5.5;                             //mean effective
    pressure in bar
9  k=0.5;                               //for 4-stroke
    cylinder
10
11 //INDICTED POWER, I.P.=(n*PMI*l*A*N*k*10)/6 kW
12 //A=(pi/4)*D^2,
13 //L=1.5D,
14 D=((6*P)/(10*k*N*n*Pmi*1.5*(%pi/4)))^(1/3);    //
    bore diameter in m
15 L=1.5*D;                             //
    length of stroke in m
16
17 printf('The Bore diameter is: %5.2 f mm.\n',(D*1000))
    ;
18 printf(' The Stoke length is: %5.2 f mm.\n',(L*1000))
    ;
```

---

### Scilab code Exa 7.3 Example 3

```
1  clc
```

```

2  clear
3  //DATA GIVEN
4  Db=0.6;                                //diameter of brake
    wheel in m
5  d=0.026;                              //diameter of rope in
    m
6  W=200;                                //dead load on the
    brake in N
7  S=30;                                //spring balance
    reading in N
8  N=450;                                //engine speed in R.P.
    M.
9
10 //Brake Power, B.P.=(W-S)(pi)(Db+d)N/(60*1000) kW
11 BP=(W-S)*(%pi)*(Db+d)*N/(60*1000);
12
13 printf('The Brake Power, B.P. is: %2.1f kW.\n',BP);

```

---

#### Scilab code Exa 7.4 Example 4

```

1  clc
2  clear
3  //DATA GIVEN
4  T=175;                                //torque due to brake load
    in Nm
5  N=500;                                //engine speed in R.P.M.
6
7  //Brake Power, BP = (2*pi)NT/(60*1000) kW
8  BP = (2*%pi)*N*T/(60*1000);
9
10 printf('The Brake Power, B.P. is: %4.2f kW.\n',BP);

```

---

#### Scilab code Exa 7.5 Example 5

```

1  clc
2  clear
3  //DATA GIVEN
4  D=0.3;                                //bore of engine
    cylinder in m
5  L=0.45;                              //stroke length in m
6  N=300;                               //engine speed in R.P.
    M.
7  Pmi=6;                               //mean effective
    pressure in bar
8  NBL=1.5;                             //Net brake load (W-S)
    in kN
9  Db=1.8;                              //diameter of brake
    drum
10 d=0.02;                             //brake rope diameter
11 n=1;                                 //no. of cylinders
12 k=0.5;                               //for 4-stroke
    cylinder
13
14 //INDICTED POWER , I.P.=(n*PMI*l*A*N*k*10)/6 kW
15 A=(%pi/4)*(D^2);
16 IP=(n*Pmi*L*A*N*k*10)/6;
17 BP=NBL*(%pi)*(Db+d)*N/(60);
18 eta=BP/IP;                           //mechanical
    efficiency
19
20 printf(' (i) The Indicted Power, I.P. is: %5.2f kW.
    \n',IP);
21 printf(' (ii) The Brake Power, B.P. is: %5.2f kW. \n
    ',BP);
22 printf('(iii) Mechanical efficiency is: %5.4f or %5
    .2f percent.\n',eta,(eta*100));

```

---

**Scilab code Exa 7.6 Example 6**

```

1  clc
2  clear
3  //DATA GIVEN
4  D=0.2;                                //diameter of engine
    cylinder in m
5  L=0.350;                             //length of stroke in
    m
6  Pmico=6.5;                           //mean effective
    pressure on cover side in bar
7  Pmicr=7;                             //mean effective
    pressure on crank side in bar
8  N=420;                               //engine speed in R.P.
    M.
9  Drod=0.02;                           //diameter of piston
    rod in m
10 W=1370;                              //dead load on the
    brake in N
11 S=145;                               //spring balance
    reading in N
12 Db=1.2;                              //diameter of brake
    wheel in m
13 d=0.02;                              //diameter of rope in
    m
14 n=1;                                 //no. of cylinders
15 k=0.5;                               //for 4-stroke
    cylinder
16
17 //INDICTED POWER , I.P.=(n*Pmi*l*A*N*k*10)/6 kW
18 Aco=(%pi/4)*(D^2);                  //area of
    cylinder om cover end in m^2
19 Acr=(%pi/4)*(D^2-Drod^2);           //area of
    cylinder om crank end in m^2
20 IPco=(n*Pmico*L*Aco*N*k*10)/6;      //IP on cover end
    side in kW
21 IPcr=(n*Pmicr*L*Acr*N*k*10)/6;      //IP on crank end
    side in kW
22 IPtotal=IPco+IPcr;                  //IP total in kW
23

```

```

24 //Brake Power , B.P.=(W-S) ( pi ) (Db+d)N/(60*1000) kW
25 BP=(W-S)*(%pi)*(Db+d)*N/(60*1000);
26
27 eta=BP/IPtotal; //mechanical
    efficiency
28
29 printf('Mechanical efficiency is: %5.4f or %5.2f
    percent.\n',eta,(eta*100));

```

---

#### Scilab code Exa 7.7 Example 7

```

1  clc
2  clear
3  //DATA GIVEN
4  IP=30; //indicted power in kW
5  BP=26; //Brake Power in kW
6  N=1000; //engine speed in R.P.M
7  F=0.35; //fuel per brake power
    hour in kg/BP/h
8  C=43900; //calorific value of
    fuel used in kJ/kg
9
10 Fc=F*BP; //fuel consumption per
    hour
11 Mf=Fc/3600;
12 ETAti=IP/(Mf*C); //Indicted thermal
    efficiency
13 ETAtb=BP/(Mf*C); //Brake thermal
    efficiency
14 ETAm=BP/IP; //Mechanical efficiency
15
16 printf(' (i) The Indicted thermal efficiency is: %5.3
    f or %2.1f percent. \n',ETAti,(ETAti*100));
17 printf(' (ii) The Brake thermal efficiency is: %5.3f

```

```

        or %2.1f percent. \n',ETAtb,(ETAtb*100));
18 printf('(iii) Mechanical efficiency is: %5.3f or %2
        .1f percent. \n',ETAm,(ETAm*100));

```

---

### Scilab code Exa 7.8 Example 8

```

1  clc
2  clear
3  //DATA GIVEN
4  Db=0.75; //diameter of brake
   pulley in m
5  d=0.05; //diameter of rope in
   m
6  W=400; //dead load on the
   brake in N
7  S=50; //spring balance
   reading in N
8  Fc=4.2; //fuel consumption in
   kg/hr
9  N=1000; //rated engine speed
   in R.P.M.
10 C=43900; //calorific value of
   fuel used in kJ/kg
11 n=1; //no. of cylinders
12 k=0.5; //for 4-stroke
   cylinder
13
14
15 //Brake Power, B.P.=(W-S)(pi)(Db+d)N/(60*1000) kW
16 BP=(W-S)*(pi)*(Db+d)*N/(60*1000);
17 sfc=Fc/BP; //brake
   specific fuel consumption in kg/kWhr
18 Mf=Fc/3600;
19 ETAtb=BP/(Mf*C); //Brake
   thermal efficiency

```

```

20
21 printf(' (i) The Brake specific fuel consumption , s.
    f.c (brake) is: %5.3f kg/kWh. \n',sfc);
22 printf(' (ii) The Brake thermal efficiency is: %5.3f
    or %2.1f percent. \n',ETAtb,(ETAtb*100));

```

---

### Scilab code Exa 7.9 Example 9

```

1  clc
2  clear
3  //DATA GIVEN
4  n=6; //no. of cylinders
5  D=0.09; //bore of each
    cylinder in m
6  L=0.1; //length of stroke in
    m
7  r=7; //compression ratio
8  ETAre1=0.55; //relative efficiency
9  Fsc=0.3; //indicated specific
    fuel consumption in kg/kWh
10 Pmi=8.6; //indicated mean
    effective pressure in bar
11 N=2500; //engine speed in R.P.
    M.
12 k=0.5; //for 4-stroke
    cylinder
13
14 //Air standard efficiency , ETAair=1-1/(r^(gamma-1))
15 g=1.4; //gamma of air=1.4
16 ETAair=1-1/(r^(g-1));
17 //Indicated thermal efficiency , ETAre1=ETAthi/ETAair
    ;
18 ETAthi=ETAre1*ETAair;
19 //Indicted thermal efficiency , ETAthi=IP/(Mf*C)
20 Mf=Fsc/3600;

```

```

21 //taking IP=1,
22 C=1/(ETAthi*Mf); //calorific value in
    kJ/kg
23 //INDICTED POWER ,I.P.=(n*Pmi*l*A*N*k*10)/6 kW
24 A=(%pi/4)*(D^2);
25 IP=(n*Pmi*L*A*N*k*10)/6;
26 Fc=Fsc*IP; //total fuel
    consumption in kg/hr
27
28 printf(' (i) The Calorific value of coal, C is: %5.0
    f kJ/kg. \n',C);
29 printf(' (ii) The Fuel consumption is: %5.2 f kg/h. \
    n',Fc);
30
31 //NOTE:
32 //ans of calorific value here is exact, while in TB
    its rounded off value

```

---

#### Scilab code Exa 7.10 Example 10

```

1  clc
2  clear
3  //DATA GIVEN
4  n=4; //no. of cylinders
5  BP=30; //Brake Power in kW
6  N=2500; //engine speed in R.P.
    M.
7  Pmi=8; //mean effective
    pressure in bar
8  ETAm=0.8; //mechanical
    efficiency
9  ETAthb=0.28; //brake thermal
    efficiency
10 C=43900; //calorific value of
    fuel used in kJ/kg

```

```

11 k=1;                                //for 2-stroke
    cylinder
12
13 //mechanical efficiency , ETAm=BP/IP
14 IP=BP/ETAm;
15 //INDICTED POWER , I.P.=(n*PMI*l*A*N*k*10)/6 kW
16 //L=1.5D,
17 D=((6*IP)/(10*k*N*n*Pmi*1.5*(%pi/4)))^(1/3);    //
    bore diameter in m
18 L=1.5*D;                                //
    length of stroke in m
19 //Brake thermal efficiency , ETAtb=BP/(Mf*C)
20 Mf=BP/(ETAtb*C);                        //
    fuel consumption in kg/hr
21
22 printf(' (i) The Bore diameter is: %5.3f m or %2.0f
    mm.\n',D,(D*1000));
23 printf('          The Stoke length is: %2.0f mm.\n',(L
    *1000));
24 printf(' (ii) The Fuel consumption is: %5.5f kg/s or
    %3.2f kg/hr. \n',Mf,(Mf*3600));

```

---

#### Scilab code Exa 7.11 Example 11

```

1 clc
2 clear
3 //DATA GIVEN
4 n=6;                                //no. of cylinders
5 Pdisp=700;                          //piston disp per
    cylinder in cm^3
6 P=78;                                //power developed in
    kW
7 N=3200;                              //engine speed in R.P.
    M.
8 Mf=27;                               //mass of fuel used in

```

```

kg/hr
9 C=44000; //calorific value of
fuel used in kJ/kg
10 afr=12; //air fuel ratio
11 Pa=0.9; //intake air pressure
in bar
12 Ta=32+273; //intake air
tempertaure in K
13 R=0.287; //gas constant for air
in kJ/kgK
14 k=0.5; //for 4-stroke
cylinder
15
16 Ma=afr*Mf; //mass of
air
17 //by eq. pa*Va=Ma*R*Ta
18 Va=Ma*R*Ta/Pa/100; //volume of
intake air in m^3/hr
19 Vswept=(Pdisp/10^6)*n*(N/2)*60; //volume
swept in m^3/hr
20 ETAvol=Va/Vswept; //volumetric
efficiency
21
22 //Brake thermal efficiency , ETAbt=brake work/heat
supplied by the fuel
23 ETAbt=P/(Mf*C/3600);
24 //Brake Power, BP = (2*pi)N*Tb/(60*1000) kW
25 Tb=P*60/(2*pi*N); //brake
torque in kNm
26
27 printf(' (i) The Volumetric efficiency is: %5.3f or
%5.1f percent. \n',ETAvol,(ETAvol*100));
28 printf(' (ii) The Brake thermal efficiency is: %5.4
f or %5.2f percent. \n',ETAbt,(ETAbt*100));
29 printf(' (iii) The Brake Torque is: %5.4f kNm. \n',
Tb);

```

---

Scilab code Exa 7.12 Example 12

```
1  clc
2  clear
3  //DATA GIVEN
4  //L=1.5D
5  n=6;                      //no. of cylinders
6  Vs=1.75;                  //stroke volume in
    litres
7  IP=26.3;                  //power developed in
    kW
8  Ne=504;                   //engine speed in R.P.
    M.
9  Pmi=6;                    //mean effective
    pressure in bar
10 k=0.5;                    //for 4-stroke
    cylinder
11
12 //INDICTED POWER ,I.P.=(n*PMI*l*A*N*k*10)/6 kW
13 //L*A=Vs
14 Na=IP*6/(n*Pmi*(Vs/10^3)*k*10); //actual speed
    in R.P.M
15 Fa=Na*n*k;                //actual no. of
    fires in one minute
16 Fe=Ne*n/2;                //expected no.
    of fires in one minute
17 Fm=Fe-Fa;                 //misfires per
    minute
18 Fmavg=Fm/n;               //avg. no. of
    times each cylinder misfires in one minute
19
20 printf('The Average no. of times each cylinder
    misfires in one minute is: %1.0f.\n',Fmavg);
```

---

### Scilab code Exa 7.13 Example 13

```

1  clc
2  clear
3  //DATA GIVEN
4  D=0.075;           //bore in m
5  L=0.09;           //stroke length in m
6  n=4;              //no. of cylinders
7  erar=39/8;         //engine to rear axle
   ratio =39:8
8  Dw=0.65;          //wheel diameter with
   tyre fully inflated in m
9  Fc=0.227;         //petrol consumption
   for a distance of 3.2 km at a speed of 48 km/hr
10 Pmi=5.625;        //mean effective
   pressure in bar
11 C=43470;          //calorific value of
   fuel used in kJ/kg
12 k=0.5;            //for 4-stroke
   cylinder
13
14 s=48*1000/60;     //speed of car in m/
   min
15 //if Nt rev are made by tyre per minute, speed=pi*Dw
   *Nt
16 Nt=s/(%pi*Dw);    //R.P.M.
17 //as engine to rear axle ratio is 39:8
18 Ne=erar*Nt;       //speed of engine
   shaft in R.P.M.
19 //INDICTED POWER , I.P.=(n*PMI*l*A*N*k*10)/6 kW
20 A=(%pi/4)*(D^2);
21 IP=(n*Pmi*L*A*Ne*k*10)/6;
22
23 s=s/1000;         //speed of car in km/

```

```

    min
24  t=3.2/s;                      //time in min for
    covering 3.2 km
25  //petrol consumption for a distance of 3.2 km at a
    speed of 48 km/hr is 0.227kg
26  Mf=Fc/(t*60);                //fuel consumed per
    sec
27  ETAthi=IP/(Mf*C);            //Indicated fuel
    efficiency
28
29  printf(' (i) The Indicated Power developed is: %5.2f
    kW. \n',IP);
30  printf(' (ii) The Indicated thermal efficiency is:
    %1.3f or %2.1f percent. \n',ETAthi,(ETAthi*100));

```

---

#### Scilab code Exa 7.14 Example 14

```

1  clc
2  clear
3  //DATA GIVEN
4  D=0.25;                      //cylinder diameter in
    m
5  L=0.4;                      //stroke length in m
6  Pmg=7;                      //Gross mean effective
    pressure in bar
7  Pmp=0.5;                    //Pumping mean
    effective pressure in bar
8  N=250;                      //engine speed in R.P.
    M.
9  NBL=1080;                   //net load on the
    brake (W-S) in N
10 Db=1.5;                    //effective diameter
    of the brake in m
11 Fc=10;                     //fuel used per hr in
    kg

```

```

12 C=44300;                                //calorific value of
    fuel used in kJ/kg
13 n=1;                                    //no. of cylinders
14 k=0.5;                                  //for 4-stroke
    cylinder
15
16 //INDICTED POWER , I.P.=(n*PMI*l*A*N*k*10)/6 kW
17 Pm=Pmg-Pmp;
18 A=(%pi/4)*(D^2);
19 IP=(n*Pm*L*A*N*k*10)/6;
20 BP=NBL*(%pi)*(Db)*N/(60*1000);
21 ETAm=BP/IP;                             //mechanical
    efficiency
22 Mf=Fc/3600;
23 ETAthi=IP/(Mf*C);                       //Indicated thermal
    efficiency
24
25 printf(' (i) The Indicated Power, I.P. is: %5.2f kW.
    \n',IP);
26 printf(' (ii) The Brake Power, B.P. is: %2.1f kW. \n
    ',BP);
27 printf('(iii) Mechanical efficiency is: %5.3f or %2
    .1f percent.\n',ETAm,(ETAm*100));
28 printf(' (iv) Indicated thermal efficiency is: %5.3f
    or %2.1f percent.\n',ETAthi,(ETAthi*100));

```

---

#### Scilab code Exa 7.15 Example 15

```

1 clc
2 clear
3 //DATA GIVEN
4 ETAthb=30;                               //Brake thermal
    efficiency in %
5 afr=20;                                  //air fuel ratio by
    weight

```

```

6 C=41800;                                //calorific value of
    fuel used in kJ/kg
7
8 //Brake thermal efficiency , ETAtb=work produced/
    heat supplied
9 work=(ETAtb/100)*C;                      //work produced per kg
    of fuel
10 //STP conditions refer to 1.0132 bar and 15 deg
    celsius
11 m=afr;                                  //mass of air per kg
    of fuel
12 R=287;
13 V=m*R*(15+273)/(1.0132*10^5); //volume of air used
14 //Brake mean effective pressure , Pmb=work done/
    cylinder volume
15 Pmb=(work*1000)/(V*10^5);
16
17 printf('The Brake mean effective pressure , Pmb is :
    %2.2f bar.\n',Pmb);

```

---

#### Scilab code Exa 7.16 Example 16

```

1 clc
2 clear
3 //DATA GIVEN
4 V1=0.216;                                //gas consumption in m
    ^3/min
5 P1=75;                                    //gas temperature in
    mm of water
6 T1=17+273;                               //gas tempertaure in K
7 m=2.84;                                   //air consumption in
    kg/min
8 Ta=17+273;                               //air tempertaure in K
9 br=745;                                   //barometer reading in
    mm of Hg

```

```

10 D=0.25; //bore of engine
    cylinder in m
11 L=0.475; //stroke length in m
12 N=240; //engine speed in R.P.
    M.
13 R=287; //gas constant for air
    in J/kgK
14 n=1; //no. of cylinders
15 k=1; //for 2-stroke
    cylinder

16
17 P1=br+P1/13.6; //pressure of the gas
18 //at NTP
19 P2=760; //mm of Hg
20 T2=0+273; //in K
21 //P1*V1/T1=P2*V2/T2
22 V2=P1*V1*T2/(P2*T1); //volume of gas used
    at NTP in m^3
23 Vg=V2/(N/2); //gas used per stroke
    in m^3

24
25 //PV=mRT
26 P2=1.0132*10^5;
27 V=m*R*T2/P2; //volume occupied by
    air in m^3/min
28 Va=V/(N/2); //air used per stroke
    in m

29
30 Vmix=Vg+Va; //mixture of gas and
    air in m^3

31
32 //ETAvol=(actual volume of mixture drawn per stroke
    at NTP)/(swept volume of system)
33 ETAvol=Vmix/((%pi/4)*D^2*L);
34
35 printf(' The Volumetric efficiency is: %3.3f or %3.1
    f percent. \n',ETAvol,(ETAvol*100));

```

---

### Scilab code Exa 7.17 Example 17

```

1  clc
2  clear
3  //DATA GIVEN
4  t=1;                                //duration of trial in
    hr
5  N=14000;                            //revolutions
6  mc=500;                             //no. of missed cycles
7  NBL=1470;                           //Net brake load (W-S)
    in N
8  Pmi=7.5;                            //mean effective
    pressure in bar
9  Vg=20000/3600;                      //gas consumption in
    litres/s
10 C=21;                               //LCV of gas at supply
    conditions in kJ/litre
11 D=0.25;                             //cylinder diameter in
    m
12 L=0.4;                              //stroke length in m
13 Cb=4;                               //effective brake
    circumference in m
14 r=6.5;                              //compression ratio
15 n=1;                                //no. of cylinders
16 k=0.5;                              //for 4-stroke
    cylinder
17
18 //gamma for air , g=1.4
19 g=1.4;
20
21 //INDICTED POWER , I.P.=(n*PMI*1*A*N*k*10)/6 kW
22 Nk=(N*k-mc)/60;                     //(N*k)-working cycles
    /min
23 A=(%pi/4)*(D^2);

```

```

24 IP=(n*Pmi*L*A*Nk*10)/6;
25 N=N/60;
26 BP=NBL*(Cb)*N/(60*1000);
27 eta=BP/IP;                                //mechanical
    efficiency
28 ETAthi=IP/(Vg*C);                          //Indicated thermal
    efficiency
29
30 //relative efficiency , ETAre1=ETAthi/ETAas
31 //ETAas=1-1/(r^(g-1))
32 ETAas=1-1/(r^(g-1));                      //air-standard
    efficiency
33 ETAre1=ETAthi/ETAas;                       //relative efficiency
34
35 printf(' (i) The Indicated Power, I.P. is: %5.2f kW
    . \n',IP);
36 printf(' (ii) The Brake Power, B.P. is: %5.2f kW. \
    n',BP);
37 printf(' (iii) Mechanical efficiency is: %5.3f or %2
    .1f percent.\n',eta,(eta*100));
38 printf(' (iv) The Indicated thermal efficiency is:
    %2.2f or %2.0f percent. \n',ETAthi,(ETAthi*100));
39 printf(' (v) The Relative efficiency is: %2.3f or
    %2.1f percent. \n',ETAre1,(ETAre1*100));

```

---

# Chapter 10

## Air Compressors

Scilab code Exa 10.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  V1=1;                                //volume of air
    taken in m^3/mim
5  p1=1.013;                            //intake pressure in
    bar
6  T1=15+273;                          //intake temperature
    in K
7  p2=7;                                //delivery pressure
    in bar
8  t=1*60;                              //time in seconds
9  //law of compression ,  $pV^{1.35}=C$ 
10 n=1.35;
11 R=287;
12
13 m=p1*10^5*V1/R/T1;                  //mass of air
    delivered in kg/min
14
15 //  $(T_2/T_1)=(p_2/p_1)^{((n-1)/n)}$ ;
16 T2=T1*(p2/p1)^((n-1)/n);           //delivery temp. T2
```

```

        in K
17
18 W=(n)/(n-1)*m*R*(T2-T1)/1000;    //indicated work in
    kJ/min
19
20 IP=W/t;                            //indicated power in
    kW
21
22 printf(' The Indicated power, IP is: %1.2f kW. \n',
    IP);

```

---

#### Scilab code Exa 10.2 Example 2

```

1  clc
2  clear
3  //continued from Example 1
4  //DATA GIVEN
5  V=1;                                //volume dealt with
    per min at inlet in m3/min
6  Vc=1/300;                          //volume drawn in
    per cycle, in m3/cycle
7  r=1.5;                             //stroke to bore
    ratio
8  ETAc=0.85;                         //mechanical
    efficiency of the compressor
9  ETAmt=0.90;                        //mechanical
    efficiency of the motor transmission
10
11 //cylinder volume, Vc=(pi/4)D2*L
12 D=[(Vc*4/%pi)/r]^(1/3);           //bore in m
13
14 //from example 1
15 Pi=4.23/ETAc;                      //power input to the
    compressor in kW
16 MP=Pi/ETAmt;                       //motor power in kW

```

```

17
18 printf(' (i) The Cylinder bore ,D is: %3.1f mm. \n',(
    D*1000));
19 printf(' (ii) The Motor power is: %1.2f kW. \n',MP);

```

---

### Scilab code Exa 10.3 Example 3

```

1  clc
2  clear
3  //DATA GIVEN
4  T1=20+273;           //temperature in K
5  p1=1;                //pressure in bar
6  p2=10;               //pressure in bar
7  Cv=0.718;            //in kJ/kgK
8
9  //law of compression ,  $pV^{1.2}=C$ 
10 n=1.2;
11 R=0.287;             //in kJ/kgK
12
13 //(T2/T1)=(p2/p1)^((n-1)/n);
14 T2=T1*(p2/p1)^((n-1)/n); //temp. T2 in K
15 m=1;
16 W=(n)/(n-1)*m*R*T1*[(p2/p1)^((n-1)/n)-1]; //
    work done per kg of air (kJ/kg of air)
17
18 //By the First Law of Thermodynamics
19 //heat transferred during compression ,  $Q=W+DU$ 
20 //Q=(p1V1-p2V2)/(n-1)+Cv(T2-T1)
21 //Q=(T2-T1)*[Cv-R/(n-1)]
22 Q=(T2-T1)*[Cv-R/(n-1)];
23
24 printf(' (i) The Temperature at the end of
    compression is: %3.0f K or %3.0f deg. celsius. \n
    ',T2,(T2-273));
25 printf(' (ii) The Work done during compression per

```

```

kg of air is: %3.2f kJ/kg of air. \n',W);
26 printf('      The Heat transferred during
compression per kg of air is: %2.2f kJ/kg of air.
\n',Q);
27 printf('      (Negative sign indicates heat
REJECTION.) \n');

```

---

#### Scilab code Exa 10.4 Example 4

```

1  clc
2  clear
3  //DATA GIVEN
4  p1=1;                                //suction pressure
    in bar
5  T1=20+273;                          //suction
    temperature in K
6  p2=6;                                //discharge pressure
    in bar
7  T2=180+273;                          //discharge
    temperature in K
8  N=1200;                              //speed of
    compressor in R.P.M.
9  Pshaft=6.25;                         //shaft power in kW
10 Ma=1.7;                              //mass of air
    delivered in kg/min
11 D=0.14;                              //diameter in m
12 L=0.1;                               //stroke in m
13 R=287;                               //in kJ/kgK
14
15 Vd=(%pi/4)*D^2*L*N;                  //displacement
    volume for single acting compressor in m^3/min
16 FAD=Ma*R*T1/p1/10^5;                 //m^3/min
17 ETAvol=FAD/Vd*100;                  //actual volumetric
    efficiency
18

```

```

19 // (T2/T1)=(p2/p1)^((n-1)/n);
20 n=1/[1-(log(T2/T1)/log(p2/p1))];           //index of
      compression ,n
21
22 IP=(n)/(n-1)*Ma/60*R/1000*T1*[(p2/p1)^((n-1)/n)-1];
      //indicated power in kW
23
24 Piso=Ma/60*R/1000*T1*log(p2/p1);
      //isothermal power
25 ETAiso=Piso/IP*100;
      //isothermal
      efficiency
26
27 ETAMEch=IP/Pshaft*100;
      //mechanical
      efficiency
28
29 ETAovr_iso=Piso/Pshaft*100;
      //overall isothermal
      eddiciency
30
31 printf(' (i) The actual Volumetric efficiency is: %2
      .2f percent. \n',ETAvol);
32 printf(' (ii) The Indicated Power, IP is: %1.3f KW.
      \n',IP);
33 printf('(iii) The Isothermal efficiency is: %2.2f
      percent.\n',ETAiso);
34 printf(' (iv) The Mechanical efficiency is: %2.1f
      percent.\n',ETAMEch);
35 printf(' (v) The Overall isothermal efficiency is:
      %2.1f percent.\n',ETAovr_iso);

```

---

#### Scilab code Exa 10.5 Example 5

```

1 //5(b) is as follows:

```

```

2  clc
3  clear
4  //DATA GIVEN
5  m=6.75;           //mass of air in kg/min
6  p1=1;             //pressure in bar
7  T1=21+273;        //temp. in K
8  p2=1.35;          //pressure in bar
9  T2=43+273;        //temp. in K
10 DTcw=3.3;         //temp. rise of cooling
    water in deg. celsius
11 Cp=1.003;         //Cp for air in kJ/kgK
12 //gamma for air=1.4
13 g=1.4;
14
15 W=m*Cp*(T2-T1);   //work in kJ/min
16 //If the compression would have been isotropic ,
17 //T_2=T1*(rp) ^[(g-1)/g]
18 rp=p2/p1;
19 T_2=T1*(rp) ^[(g-1)/g];
20 Qr=m*Cp*(T_2-T2); //heat rejected to cooling
    water
21
22 Mw=Qr/[4.18*(DTcw)]; //mass of cooling water in
    kg/min
23
24 printf(' (i) The Work is: %3.2f kJ/min. \n',W);
25 printf(' (ii) The Mass of cooling water is: %1.2f kg
    /min. \n',Mw);
26
27 //NOTE:
28 //in the question compression process is mentioned
    and p2 is given as 0.35 bar (p2<p1)
29 //which is wrong and further p2 is given as 1.35 bar
    which is allowable
30 //so here value of p2 is taken as 1.35 bar.

```

---

### Scilab code Exa 10.6 Example 6

```

1  clc
2  clear
3  //DATA GIVEN
4  V1=14;                                //quantity of air to
    be delivered , in m3/mim
5  p1=1.013;                            //intake pressure in
    bar
6  T1=15+273;                          //intake temperature
    in K
7  p2=7;                                //delivery pressure
    in bar
8  N=300;                               //speed of
    compressor in R.P.M.
9  n=1.3;                               //compression and
    expansion index
10 R=0.287;
11
12 //clearance volume , Vc = 0.05 Vs    ,Vs=swept volume
13 //swept volume Vs=V1-V3=V1-Vc=V1-0.05Vs
14 //V1=1.05Vs
15 Vpc=V1/N/2;
                                     //(
    V1-V4) volume induced per cycle in m3
16 //V4/V3=(p2/p1)^(1/n)
17 c=(p2/p1)^(1/n);
18 //V4=c*V3=c*0.05Vs
19 //V1-V4=1.05Vs-c*0.05Vs
20 Vs=Vpc/(1.05)/(1.05-c*0.05);
                                     //volume swept in m3
21
22 //using relation (T2/T1)=(p2/p1)^((n-1)/n);
23 T2=T1*(p2/p1)^((n-1)/n);

```

```

//delivery temp.
    T2 in K
24
25 IP=(n)/(n-1)*p1*10^5*Vpc/100*[(p2/p1)^((n-1)/n)-1];
    //indicated power in kW
26
27 printf(' (i) The Swept volume of the cylinder , Vs is
    : %1.4f m^3. \n',Vs);
28 printf(' (ii) The delivery temperature , Ts is: %3.0f
    deg. celsius. \n',(T2-273));
29 printf('(iii) The Indicated power , IP is: %2.2f kW.
    \n',IP);
30
31 //NOTE:
32 //there is slight variation in answers in textbook
    due to rounding off of values in book

```

---

# Chapter 13

## Transmission of Motion and Power

Scilab code Exa 13.1 Example 1

```
1  clc
2  clear
3  //DATA GIVEN
4  N1=240;                                //speed of the engine
   shaft in R.P.M.
5  d1=1.5;                                //diameter of pulley on
   engine shaft in m
6  d2=0.75;                                //diameter of pulley on
   machine shaft in m
7  t=0.005;                                //thickness of the belt
   in m
8
9  //with no slip
10 //  $(N2/N1) = (d1+t)/(d2+t)$ 
11 N2=(d1+t)/(d2+t)*N1;                    //speed of the machine
   shaft in R.P.M.
12
13 //with slip of 2%
14 S=2;                                    //slip in %
```

```

15 // (N2/N1)=(d1+t)/(d2+t)*((100-S)/100)
16 N2s=(d1+t)/(d2+t)*N1*((100-S)/100);
17
18 printf(' (i) The Speed of machine shaft , N2 with no
        slip is: %4.1f R.P.M. \n',N2);
19 printf(' (ii) The Speed of machine shaft , N2 with
        slip of 2 percent is: %4.1f R.P.M. \n',N2s);

```

---

### Scilab code Exa 13.2 Example 2

```

1  clc
2  clear
3  //DATA GIVEN
4  r1=900/2000;           //radius of larger
        pulley in m
5  r2=300/2000;           //radius of smaller
        pulley in m
6  d=6;                   //distance between the
        centres of pulley in m
7
8  //Length of cross belt , Lcross=(pi)(r1+r2)+(r1+r2)
        ^2/d+2d;
9  Lcross=(%pi)*(r1+r2)+(r1+r2)^2/d+2d;
10 //Length of open belt , Lopen=(pi)(r1+r2)+(r2-r1)^2/d
        +2d;
11 Lopen=(%pi)*(r1+r2)+(r2-r1)^2/d+2d;
12
13 Lred=Lcross-Lopen;      //length to be reduced
14 printf(' The Length of the belt to be reduced , \n (
        to change the direction of rotation of the
        follower pulleys)is: %2.0f mm. \n',(Lred*1000));

```

---

### Scilab code Exa 13.3 Example 3

```

1  clc
2  clear
3  //DATA GIVEN
4  T1=1500;           //tension on the tight
   side in N
5  T2=1200;           //tension on the slack
   side in N
6  v=80;              //speed of the belt in m
   /s
7
8  P=(T1-T2)*v;        //power transmitted by
   the belt in watts
9
10 printf(' The Power transmitted by the belt is: %2.0 f
    kW. \n', (P/1000));

```

---

#### Scilab code Exa 13.4 Example 4

```

1  clc
2  clear
3  //DATA GIVEN
4  v=500;              //speed of the belt in m
   /min
5  mu=0.3;             //coefficient of
   friction
6  theta=160;          //angle of contact in
   degrees
7  T1=700;             //maximum tension in the
   belt in N
8
9  /(T1/T2)=e^(mu*theta)
10 theta=theta*(%pi)/180; //theta converted into
   radians
11 T2=T1/(%e^(mu*theta)); //tension on the slack
   side in N

```

```

12 v=v/60;                                //speed of the belt
    converted into m/s
13 P=(T1-T2)*v;                            //power transmitted by
    the belt in watts
14
15 printf(' The Power transmitted by the belt is: %2.3 f
    kW. \n', (P/1000));

```

---

### Scilab code Exa 13.5 Example 5

```

1  clc
2  clear
3  //DATA GIVEN
4  r1=750/2000;                            //radius of larger
    pulley in m
5  r2=300/2000;                            //radius of smaller
    pulley in m
6  d=1.5;                                  //distance between the
    centres of pulley in m
7  Tms=14;                                 //maximum safe tension
    in N/mm
8  b=150;                                  //width of the belt in
    mm
9  v=540;                                  //speed of the belt in m
    /min
10 mu=0.25;                                //coefficient of
    friction
11
12 T1=Tms*b;                               //maximum tension in the
    belt in N
13 v=v/60;                                  //speed of the belt
    converted into m/s
14 //(i) for open belt
15 ALPHAo=asin ((r1-r2)/d)*180/(%pi);      //alpha in
    degrees

```

```

16 THETAo=180-2*ALPHAo;           //angle of
    lap or contact in deg
17 T2o=T1/((%e^(mu*(THETAo*%pi/180)))); //tension on
    the slack side in N
18 Po=(T1-T2o)*v;                 //power
    transmitted by the belt in watts
19
20 //(ii) for cross belt
21 ALPHAc=asin ((r1+r2)/d)*180/(%pi); //alpha in
    degrees
22 THETAc=180+2*ALPHAc;           //angle of
    lap or contact in deg
23 T2c=T1/((%e^(mu*(THETAc*%pi/180)))); //tension on
    the slack side in N
24 Pc=(T1-T2c)*v;                 //power
    transmitted by the belt in watts
25
26 printf(' (i) The Maximum Power transmitted by the
    open belt is: %2.3f kW. \n',(Po/1000));
27 printf(' (ii) The Maximum Power transmitted by the
    cross belt is: %2.3f kW. \n',(Pc/1000));

```

---

#### Scilab code Exa 13.6 Example 6

```

1 clc
2 clear
3 //DATA GIVEN
4 b=0.25;           //width of the belt in m
5 t=0.006;          //thickness of the belt
    in m
6 r=900/2000;       //radius of the pulley
    in m
7 rho=1100;          //density of the
    material in kg/m^3
8 Tp=2;              //permissible tension of

```

```

        the belt in MN/m^2
9  ratio=2;                                //ratio of T1/T2=2
10 N=200;                                  //speed of the pulley in
        R.P.M.
11
12 Tmax=Tp*10^6*b*t;                       //maximum safe tension
        of the belt
13 //centrifugal tension , Tc=m*v^2
14 m=(b*t)*1*rho;                          //mass of the belt per
        unit metre length
15 v=2*(%pi)*(r+t/2)*N/60;
16 Tc=m*v^2;
17
18 T1=Tmax-Tc;                             //tension in the tight
        side in N
19 T2=T1/ratio;                             //tension in the slack
        side in N
20 P=(T1-T2)*v;                             //power transmitted by
        the belt in watts
21
22
23 printf(' (i) The Centrifugal tension Tc is: %3.1f N.
        \n',Tc);
24 printf(' (ii) The Power transmitted by the belt is:
        %2.1f kW. \n',(P/1000));

```

---

#### Scilab code Exa 13.7 Example 7

```

1  clc
2  clear
3  //DATA GIVEN
4  P=35;                                    //power required to be
        transmitted by the belt in kW
5  d=1.5;                                  //effective diameter of
        pulley in m

```

```

6  N=300;                                //speed of the pulley in
    R.P.M.
7  theta=11/24*2*%pi;                    //angle of contact in
    radians
8  mu=0.3;                                //coefficient of
    friction
9  t=0.0095;                              //thickness of the belt
    in m
10 rho=1100;                              //density of the
    material in kg/m^3
11 sigma=2.5;                             //permissible stress in
    MN/m^2
12
13 v=%pi*d*N/60;                          //speed of the belt in m
    /s
14 //P=(T2-T1)*v, so (T2-T1)=P/v.....(1)
15 c=%e^(mu*theta);                       //so, T2/T1=c.....(2)
16 //By equation (1) and (2),
17 T2=(P/v*1000)/(c-1);                   //tension in the slack
    side in N
18 T1=c*T2;                               //tension in the tight
    side in N
19
20 //maximum tension, Tmax=sigma*b*t=0.2375*b*10^6 N
    (3)
21 //centrifugal tension, Tc=m*v^2=5800.5*b N
    (4)
22 //T1=Tmax-c
    (5)
23 //By eqn. (3),(4) and (5)
24 b=T1/((sigma*10^6*t)-(t*1*rho*v^2));    //width of
    the belt in m
25
26 printf(' The Width of the belt is: %3.0f mm (say 150
    mm). \n',(b*1000));

```

---

### Scilab code Exa 13.8 Example 8

```
1  clc
2  clear
3  //DATA GIVEN
4  b=0.2;           //width of the belt in m
5  t=0.01;         //thickness of the belt
                    in m
6  Tp=2;           //permissible tension of
                    the belt in MN/m^2
7  ratio=1.8;      //ratio of T1/T2=1.8
8  rho=1100;       //density of the
                    material in kg/m^3
9
10 Tmax=Tp*10^6*b*t; //maximum safe tension
                    of the belt
11 //we know centrifugal tension , Tc=Tmax/3
12 Tc=Tmax/3;
13 //centrifugal tension , Tc=m*v^2
14 m=(b*t)*1*rho;   //mass of the belt per
                    unit metre length
15 v=(Tc/m)^0.5;
16
17 T1=Tmax-Tc;      //tension in the tight
                    side in N
18 T2=T1/ratio;     //tension in the slack
                    side in N
19 P=(T1-T2)*v;     //power transmitted by
                    the belt in watts
20
21 printf(' (i) The Velocity of the belt is: %3.1f m/s.\n',v);
22 printf(' (ii) The Maximum power transmitted by the
    belt is: %2.2f kW. \n',(P/1000));
```

---

### Scilab code Exa 13.9 Example 9

```

1  clc
2  clear
3  //DATA GIVEN
4  To=1000;           //initial tension in the
    belt in N
5  theta=150;        //angle of embrace in
    degrees
6  mu=0.25;          //coefficient of
    friction
7  v=500;            //speed of the belt in m
    /min
8
9  //Initial tension , To=(T1+T2)/2
10 //so , (T1+T2) = 2000 ..... (1)
11 theta=theta*(%pi)/180; //theta converted into
    radians
12 c=%e^(mu*theta);    //so , T2/T1=c ..... (2)
13 //By equation (1) and (2) ,
14 T2=(To*2)/(c+1);    //tension in the slack
    side in N
15 T1=c*T2;            //tension in the tight
    side in N
16
17 v=v/60;            //speed of the belt
    converted into m/s
18 P=(T1-T2)*v;        //power transmitted by
    the belt in watts
19
20 printf(' (i) The Tension in the tight side T1 is: %4
    .0f N. \n',T1);
21 printf('          The Tension in the slack side T2 is:
    %3.1f N. \n',T2);

```

```

22 printf(' (ii) The Power transmitted by the belt is:
    %2.2f kW. \n', (P/1000));

```

---

### Scilab code Exa 13.10 Example 10

```

1  clc
2  clear
3  //DATA GIVEN
4  P=400; //maximum value of force
        that can be developed in N
5  mu=0.25; //coefficient of
        friction
6  d=0.6; //diameter of drum in m
7  //Refer the figure
8  theta=180+45; //angle of contact in
        degrees
9  theta=theta*(%pi)/180; //theta converted into
        radians
10
11 //moments about A, Ma=0,
12 T1=P*1/0.5;
13
14 //(i)Drum is rotating anticlockwise
15 //T1>T2 (T1/T2)=e^(mu*theta)
16 T2=T1/(%e^(mu*theta));
17 Mcac=(T1-T2)*(d/2); //maximum braking
        torquethat can be developed in N
18
19 //(i)Drum is rotating clockwise
20 //T2>T1 (T2/T1)=e^(mu*theta)
21 T2=T1*(%e^(mu*theta));
22 Mcc=(T2-T1)*(d/2); //maximum braking
        torquethat can be developed in N
23
24 printf(' (i) The Maximum braking torque that can be

```

```

        developed in anticlockwise direction is: %3.0f Nm
        . \n',Mcac);
25 printf(' (ii) The Maximum braking torque that can be
        developed in clockwise direction is: %3.1f Nm. \
        n',Mcc);

```

---

### Scilab code Exa 13.11 Example 11

```

1  clc
2  clear
3  //DATA GIVEN
4  Pt=80; //power to be
        transmitted by the rope in kW
5  d=1.5; //diameter of pulley in
        m
6  N=200; //speed of the pulley in
        R.P.M.
7  alpha=45/2; //semi angle of groove
        in degrees
8  theta=160; //angle of contact in
        degrees
9  mu=0.3; //coefficient of
        friction
10 m=0.6; //mass of each rope per
        unit metre length
11 Ts=800; //safe pull in N
12
13 //centrifugal tension, Tc=m*v^2
14 v=(%pi)*d*N/60; //velocity
        of the rope in m/s
15 Tc=m*v^2;
16
17 T1=Ts-Tc; //tension in
        the tight side in N
18 //(T1/T2)=e^(mu*theta)

```

```

19 theta=theta*(%pi)/180;           //theta
    converted into radians
20 alpha=alpha*(%pi)/180;           //alpha
    converted into radians
21 T2=T1/(%e^(mu*theta/sin(alpha))); //tension on
    the slack side in N
22 p=(T1-T2)*v;                     //power
    transmitted by the belt in watts
23
24 //no. of ropes required , n=Total power transmitted/
    Power transmitted by each rope
25 n=Pt/(p/1000);
26
27 //Initial tension in rope , To=(T1+T2+2Tc)/2
28 To=(T1+T2+2*Tc)/2;
29
30 printf(' (i) The Number of ropes required for the
    drives is: %1.1f say %1.0f. \n',n,n);
31 printf(' (ii) The Initial tension in the rope , To is
    : %3.2f N. \n',To);

```

---

#### Scilab code Exa 13.12 Example 12

```

1  clc
2  clear
3  //DATA GIVEN
4  T=72;           //number of teeth
5  Pc=26;          //circular pitch in mm
6
7  //circular pitch , Pc=(pi*D)/T
8  D=Pc*T/(%pi);  //pitch diameter in m
9  //Pc*Pd=(pi)
10 Pd=(%pi)/Pc;    //diametral pitch in
    teeth/mm
11 // Module , m=D/T

```

```

12 m=D/T;                                //module in mm/tooth
13
14 printf(' (i) The Pitch diameter, D is: %3.2f mm. \n
    ',D);
15 printf(' (ii) The Diametral pitch, Pd is: %1.2f
    teeth/mm. \n',Pd);
16 printf('(iii) The Module,m is: %1.2f mm/tooth. \n',m
    );

```

---

### Scilab code Exa 13.13 Example 13

```

1  clc
2  clear
3  //DATA GIVEN
4  Ta=40;                                //number of teeth of
    gear A
5  Tb=100;                                //number of teeth of
    gear B
6  Tc=50;                                //number of teeth of
    gear C
7  Td=150;                                //number of teeth of
    gear D
8  Te=52;                                //number of teeth of
    gear E
9  Tf=130;                                //number of teeth of
    gear F
10 Na=1000;                                //speed of the motor
    shaft in R.P.M.
11
12 //(Nf/Na)=(Ta/Tb)*(Tc/Td)*(Te/Tf)
13 Nf=(Ta/Tb)*(Tc/Td)*(Te/Tf)*Na;        //Speed of the
    output shaft in R.P.M.
14
15 printf(' The Speed of the output shaft, Nf is: %3.2f
    R.P.M. \n',Nf);

```

